

REPORT TO THE
DELAWARE RIVER BRIDGE JOINT COMMISSION
OF THE STATES OF
PENNSYLVANIA AND NEW JERSEY

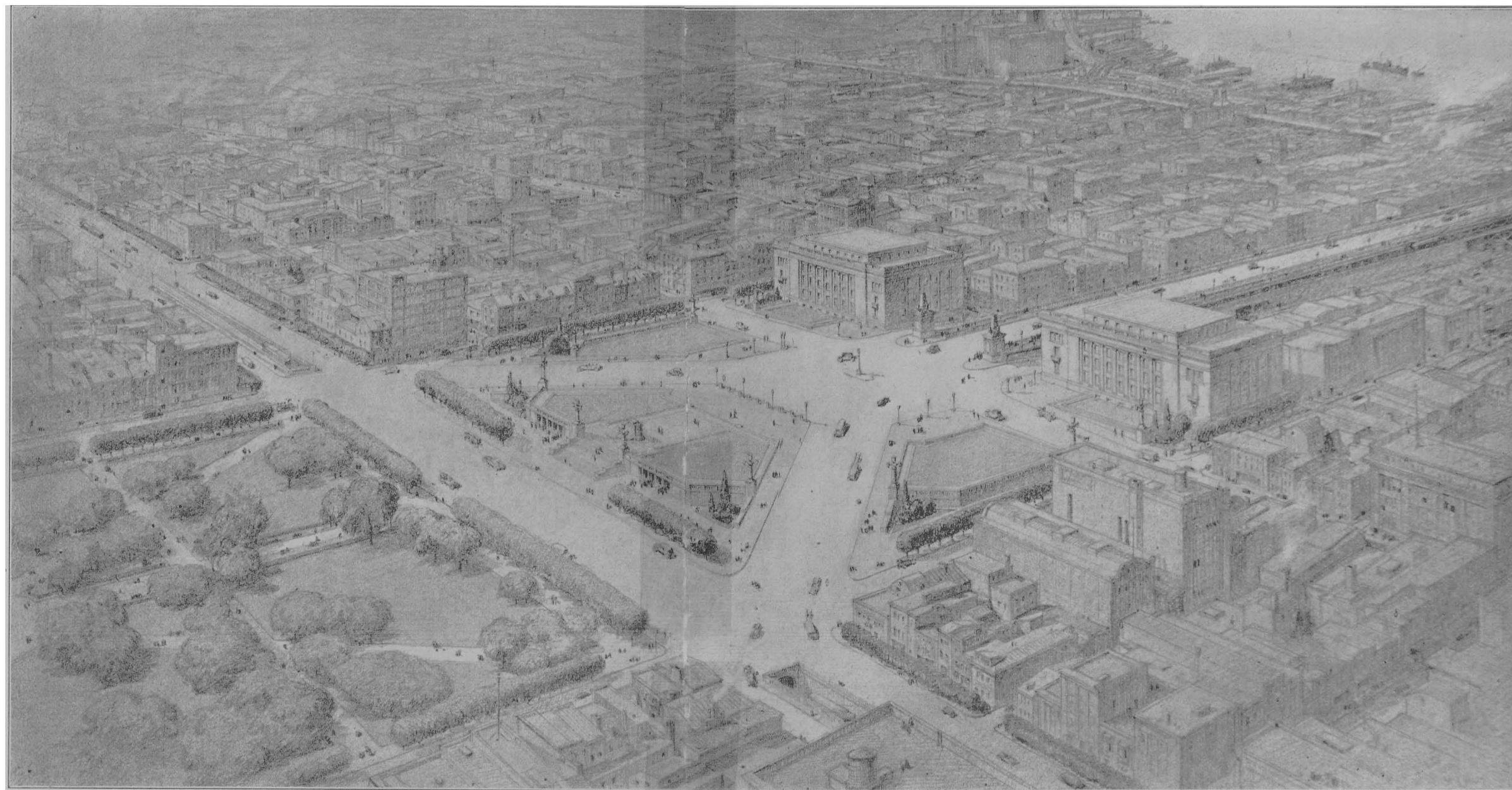
ON THE
BRIDGE OVER THE DELAWARE RIVER
CONNECTING
PHILADELPHIA, PA. & CAMDEN, N. J.

BOARD OF ENGINEERS

RALPH MODJESKI, *Chairman*

GEORGE S. WEBSTER

LAURENCE A. BALL



The Philadelphia Plaza and Approach to the Bridge, East of Franklin Square

THE DELAWARE RIVER BRIDGE JOINT COMMISSION

Authorized by Act of Pennsylvania Legislature July 9, 1919
and by Act of New Jersey Legislature, April 8, 1919

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This Report submitted by the Board of Engineers to the Joint Commission on June 9, 1921.

Public hearings were held June 13th on the Franklin Square-Pearl Street site;
June 15th on the Spring Garden-Main Street site;
June 17th on the Washington Square-Mickle Street site.

The report was approved and adopted by the Joint Commission June 23, 1921.

CENTER LINE.

The center line of the bridge, as recommended by the Board of Engineers, was confirmed on July 21, 1921, in the following resolution:

RESOLVED: That the center line of the bridge be fixed in accordance with the plan dated July 21, 1921, submitted by the Chief Engineer and approved by the Board of Engineers, to run from a point on the center line of Fifth Street three hundred and nineteen feet three inches (319 ft. 3 in.), measured north along the center line of Fifth Street from the center line of Race Street in Philadelphia, in a straight line across the river to a point on the center line of Delaware Avenue in Camden ninety-seven feet (97 ft.) measured north along the center line of Delaware Avenue from the center line of Pearl Street, Camden, and thence in an extension of the same straight line eight hundred and forty-five feet (845 ft.) to a point near and west of Second Street and thence curving towards the south with a radius of twenty-one hundred and thirteen feet (2113 ft.) a distance of eleven hundred and fifty feet (1150 ft.) to a point near and west of Fifth Street and thence on a straight line nine hundred and seventy feet (970 ft.) more or less to a point on a line midway between Sixth and Seventh Street one hundred feet (100 ft.) north of the center line of Penn Street.

REPORT
PART ONE

TO THE DELAWARE RIVER BRIDGE JOINT COMMISSION,
Gentlemen:

Acting under instructions contained in your resolution of September 24, 1920, we, your Board of Engineers, have carefully studied the character of foundations, conditions of traffic, land values and costs at the most favorable sites for a bridge over the Delaware River connecting Philadelphia, Pennsylvania and Camden, New Jersey and have prepared general plans and estimates of a structure at the recommended location, all of which are set forth and described in this report.

RECOMMENDATIONS

As a result of our investigations and studies we desire to recommend:

THAT, BY REASON OF THE MOST FAVORABLE TRAFFIC CONDITIONS COMPATIBLE WITH REASONABLE COST, THE BRIDGE BE LOCATED STARTING IN PHILADELPHIA FROM A POINT ON SIXTH STREET MIDWAY BETWEEN RACE AND VINE STREETS OPPOSITE FRANKLIN SQUARE AND CROSSING THE RIVER IN A STRAIGHT LINE TO PEARL AND SECOND STREETS IN CAMDEN, THEN CURVING SOUTHWARD TO A POINT ON PENN STREET MIDWAY BETWEEN SIXTH AND SEVENTH STREETS.

THAT THE STRUCTURE CROSS THE RIVER WITH A SINGLE SPAN 1750 FEET LONG CENTER TO CENTER OF MAIN PIERS PROVIDING AN UNOBSTRUCTED OPENING FOR NAVIGATION BETWEEN PIER-HEAD LINES.

THAT THE OVERHEAD CLEARANCE ABOVE MEAN HIGH WATER BE 135 FEET OVER A WIDTH OF 800 FEET IN THE CENTER OF THE SPAN.

THAT BY REASON OF GREATER ECONOMY AND GREATER EASE AND SAFETY OF ERECTION AND SHORTER TIME REQUIRED FOR CONSTRUCTION AS COMPARED WITH THE CANTILEVER TYPE OF BRIDGE, THE MAIN STRUCTURE BE OF A TWO CABLE SUSPENSION TYPE.

THAT THE BRIDGE AND APPROACHES BE BUILT TO PROVIDE A SINGLE DECK CARRYING AN UNOBSTRUCTED ROADWAY FOR SIX LINES OF VEHICLES, ALSO TWO LINES FOR SURFACE CARS AND TWO LINES FOR RAPID TRANSIT, AND THAT TWO TEN-FOOT SIDEWALKS BE PROVIDED ABOVE THE ROADWAY.

THAT THE FOUNDATION CAISSONS OF THE MAIN PIERS BE SUNK TO BED ROCK, WHICH IS WITHIN PRACTICABLE DEPTH AT THE RECOMMENDED LOCATION.

WE ESTIMATE THAT THE TOTAL COST OF THE BRIDGE AND APPROACHES, INCLUDING LAND DAMAGES, WILL BE \$28,871,000.

THE COST WOULD BE DIVIDED IN THE FOLLOWING MANNER:

STATE OF PENNSYLVANIA.....	\$ 8,221,000
STATE OF NEW JERSEY.....	12,429,000
CITY OF PHILADELPHIA.....	8,221,000

Total \$28,871,000

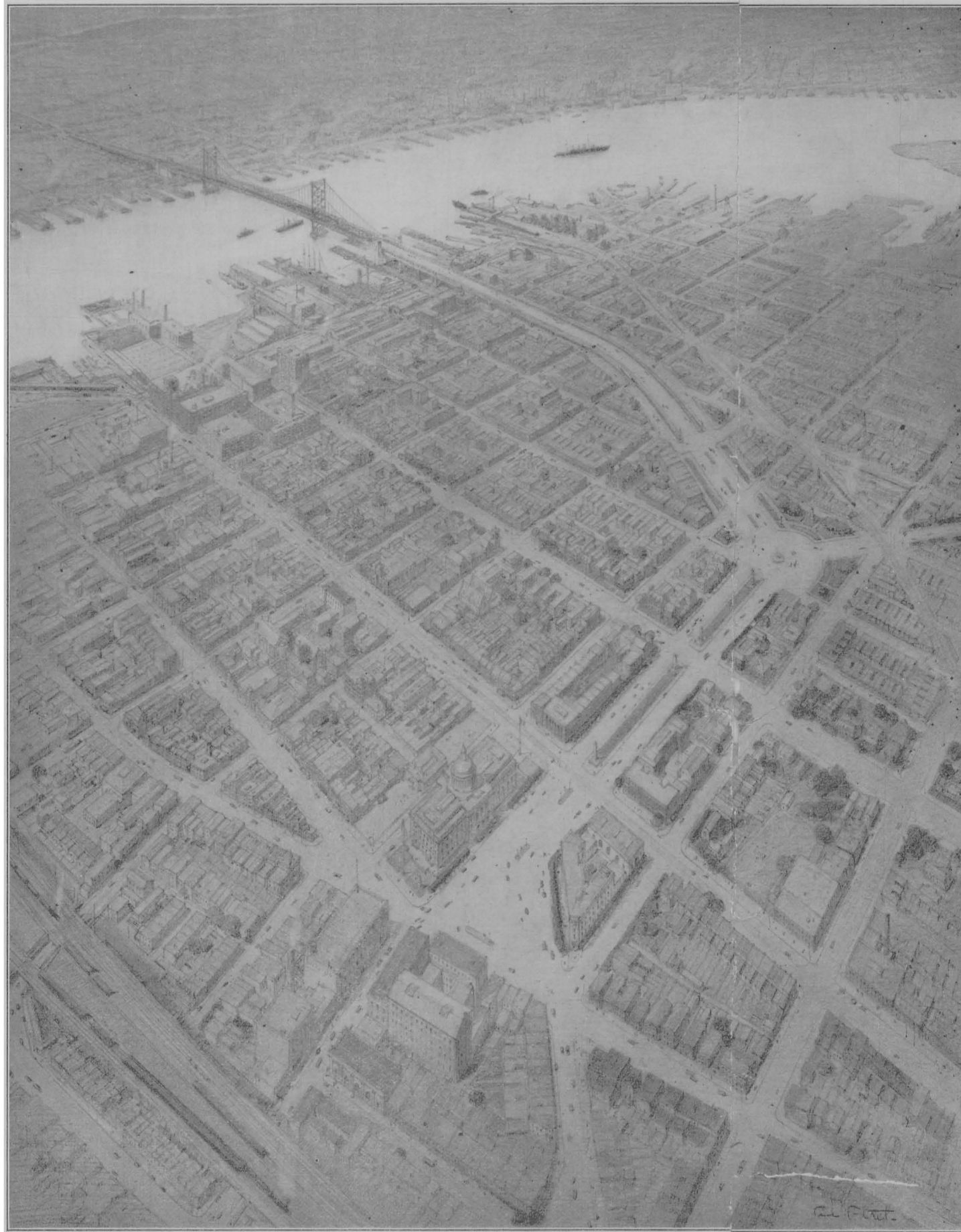
These conclusions are discussed at greater length in this report which also contains general plans showing details of the project as recommended.

COMPARISON OF BRIDGES AT POSSIBLE LOCATIONS

In your instructions you asked us to compare the three most favorable sites for a bridge over the Delaware River—giving consideration to traffic conditions, values of land, conditions of foundation and estimates of cost. Some study was needed before we were able to determine upon three sites out of the various possibilities. Between the limits fixed by the Act of Congress we found five distinctive locations, each of which is susceptible of variation in the arrangement of the approaches. As shown and numbered on Plate I, these are:

<i>Philadelphia</i>		<i>Camden</i>	
1.	Spring Garden Street	to	State Street
2.	Franklin Square	to	Pearl Street
3.	Market Street	to	Market Street
4.	Washington Square	to	Federal Street
5.	Lombard Street	to	Clinton Street

General Considerations: For the two states that, by joint legislation, have prepared the way for the construction of this bridge, it is a logical and proper extension of their state highway systems. It is to be also a direct link between the inter-related communities on the opposite banks of the river, one of which, the city of Philadelphia, will directly share in the cost of its construction. Its location, then, must be chosen with a careful balancing of the ends that it is hoped to attain and the interests of all the communities concerned. It is expected to accommodate all the classes of vehicular and passenger traffic now crossing the river and it must be a reasonable compromise of their different demands and desired routes of travel, and must further provide for the increase in this traffic during the years to come.



*The Bridge, Viewed from above Camden, with
Proposed Avenue from Plaza to Court House*

We regard the criterion for suitability of location to be convenience of use and cost of construction. Convenience must be measured not only in terms of the present traffic but of that of the future. Cost reflects directly the difficulty of construction resulting from foundation conditions, required length of span and approaches and necessary disturbance to existing structures and interference with business.

MARKET STREET-MARKET STREET SITE

Of the five sites, that extending along Market Street in the two cities seems, at first thought, to fit most naturally into the city plans. Market Street is the east and west axis of the original Philadelphia Plan, with the four squares laid out by William Penn symmetrically disposed with relation to it. The established channel of almost two-thirds of the traffic crossing the river is from the foot of Market Street to the Market-Federal Street Plaza in Camden. However, the merit of a position on the Philadelphia Plan axis is more striking on a map than in actuality—particularly as the relation between Camden and Philadelphia streets would prevent the river span and its lofty towers from being actually centered on that line. If it were to be so located, the approaches would pass through and destroy the most highly developed industrial section of Camden. Also the construction of the bridge piers directly in the path of the present ferries would require the relocation of the Philadelphia terminals and seriously interfere with the ferries during the years of their heaviest load, while the traffic that already fills Market Street would be multiplied to hopeless congestion before the bridge ever reached its maximum capacity. These considerations, aside from the excessive cost involved in the purchase of land for approaches along Market Street, rule out this site.

Market St. site with Two-Way Approach: The Market Street line for the main bridge has been suggested in connection with a bifurcated, or two-way, approach in Philadelphia. This apparently offers the possibility of keeping the river spans centered on the Philadelphia Plan axis, without overloading Market Street with the bridge traffic and at the same time meeting the desire of those both north and south of that street for approaches landing in their districts. In Camden, it would give a single approach leading into the center of the business district. One variation of this proposition has been for the approaches to split at right angles from the bridge axis at the Philadelphia anchorage and run north and south along Front Street. The other has been that they should each go diagonally, or on a curve, into two sections of the city, one north and one south of Market Street. The first scheme, in addition to the objections common to both, would require all traffic—the greater part of which goes or comes from west of Sixth Street—to pass through the busy streets near the river instead of over them on an approach.

Either scheme would require the construction of an expensive elevated plaza at the junction of the approaches and the main span to permit distribution of the traffic.

The main difficulty with the proposition, however, would be the very great cost inherent in the fact that two approaches cannot each be made one-half the width of a single approach, or be constructed without a great duplication of constructional parts and facilities. The cost of a split approach centered on Market Street would be, on account of the high value of the property necessary to be taken, from two to three times (dependent on the plan adopted) the cost of the single approach at the site we recommend.

LOMBARD ST.-CLINTON ST. SITE

The Lombard Street-Clinton Street line was at first suggested as a possible alternate to the Washington Square location for a bridge crossing the river south of Market Street. However, a bridge ending one-half mile south of Market Street is so completely at variance with the Pennsylvania traffic conditions as we find them, without offering any striking compensating advantages on the New Jersey side, as to dismiss it from serious consideration. From the indications of the test borings, rock at this location would have been found at so great a depth as to seriously increase the difficulty of securing satisfactory foundations. A main span over 100 feet longer than at the recommended site would have been required. Both of these conditions would add greatly to the cost of construction.

With these two sites eliminated, there are left as "the three most favorable sites" one location south and two north of Market Street in Philadelphia.

THE WASHINGTON SQUARE-FEDERAL STREET SITE

Whether the bridge should be located north or south of Market Street in Philadelphia was a basic question that presented itself to us, a correct answer to which involved consideration of the nature and distribution of the cross-river travel and its probable development in the future. If the answer had indicated the desirability of the south of Market position, Washington Square would offer certain advantages as a Philadelphia terminus, over others in that section.

Advantages of the Washington Square-Federal Street Site: This location was very thoroughly discussed by Dr. Warren P. Laird in his report of November 30, 1918 to the Delaware River Bridge and Tunnel Commissions of Pennsylvania and New Jersey. The Square

itself, together with the property that he recommended should be taken to the south, would offer a satisfactory site for the creation of an adequate traffic plaza, and would provide a desirable setting for whatever formal treatment it should be desired to give the bridge end. It would be convenient to Philadelphia's shopping and business district. It would serve directly the needs of that portion of the traffic caused by the shipment of New Jersey produce to the present Dock Street commission house district. In Camden the terminus has a very central location, just west of the Camden County Court House, which would lend itself well to architectural treatment. The ending of the bridge at this point brings it near the local New Jersey surface car routes and the Broadway Station of the Pennsylvania Railroad.

North or South of Market Street Best for Traffic? However, all our studies of the Philadelphia traffic situation lead us inevitably to the conclusion that there is more cross-river travel to and from the regions north of Market Street than those south of Market Street and there is every reason to believe these conditions will not change. As stated later, our vehicular census indicated a center for ordinary inter-city and inter-state travel north of Market Street at 16th and Filbert Streets. This count did not include the high season flow of New Jersey produce to Philadelphia—which centers south of Market Street—but we have found this to be not over 10% of the total and to be, moreover, offset by the northerly inclination of the travel moving in the same months by passenger automobile to the seashore resorts. Going back of this traffic census to the basic factors that affect the flow of the travel, we found the center of area within fifteen miles of Philadelphia's City Hall to be north of Market Street, as are also the centers of industrial activity and of Pennsylvania population within the same radius. The center of population was 1.4 miles north of Market Street in 1920.

New Jersey's corresponding centers are south of Camden's Market Street, but conditions there are more flexible than in Philadelphia. The highways of the tributary New Jersey districts converge to an intersection at about Sixth and Market Streets, Camden. It is not so vital whether the bridge starts north or south of this point, as that it should start from a point nearby and convenient to it.

The location which best suits the difficult conditions on the Philadelphia side of the river and which gives Camden a terminus near this New Jersey highway intersection, will therefore most adequately meet the combined needs of the partners in the bridge enterprise.

Objections to the Washington Square-Federal Street Location: No location south of Market Street will serve traffic on the Philadelphia side as well as one north of Market Street. To reach or to leave the terminus at Washington Square the majority of the vehicles would have to pass through or across Market, Chestnut and Walnut Streets. These are already congested. With their own normal increase and the addition of the bridge travel they would become hopelessly blocked. Any

plan to secure relief by sufficient widening of these streets would be so expensive as to render its carrying out impracticable.

Quite aside from the fact that it does not best meet the needs of present and future traffic, there are a number of other serious objections to the Washington Square-Federal Street line. Both the structure and the property would be the most costly of the three sites considered, a total of \$38,000,000, 31% in excess of the Franklin Square-Pearl Street location. The structure is more costly because of the greater depth to which it would be necessary to carry the main piers and the longer main river span. The property that must be taken is in one of the most valuable sections of Philadelphia.

Further, this location, as planned in the report to the previous Commissions, would involve the taking of all of Washington Square for plaza purposes. It is true that there might be provided an equivalent area of green spaces, but these would be so separated by the different busy avenues of approach to the bridge as to be largely isolated one from another. The existing character of the Square, cherished by Philadelphians through its historical associations, would be entirely destroyed. Our studies of this plaza brought out that very expensive trunk sewer reconstruction would be necessary to allow connection between the bridge rapid transit tracks and the existing or proposed Philadelphia subways.

It would not be possible to make the anchor spans nearly as long as suggested by Dr. Laird for this location, without permitting excessive deflections in the bridge and adding greatly to the cost of the main span through lack of symmetry and proper proportion. The Camden anchorage therefore, instead of clearing the Pennsylvania Railroad train shed, would have to be placed in the middle of it, involving its complete destruction and very heavy damages to the railroad. The Camden plaza is so close to the actual center of Camden's business activity that it would be necessary for most of the through traffic to force its way along these crowded streets for one or more blocks before distributing to the main highways.

For these reasons, we consider the Washington Square-Federal Street line to be less suitable for the location of this bridge than the Franklin Square-Pearl Street line herein recommended.

THE SPRING GARDEN STREET-STATE STREET LINE

The Bridge Near, or Far From, Market Street? Both the remaining sites lie north of Market Street. Leaving aside for the present the advantages particular to each site as a terminus, the question may be more

broadly viewed as to the comparative traffic convenience of a site as nearby Market Street as is Franklin Square or one as far distance as is Spring Garden Street. We believe the former to be beyond all question superior for the following reasons:

Market Street is the actual east and west axis of Philadelphia. Passenger transportation facilities focus on or near it. The center of present day cross-river vehicular travel is very nearly on Market Street. Shops, offices and factories along or near it are the destination of thousands who come from New Jersey daily to purchase goods, transact business or earn their living. We have stated that to land this traffic directly on Market Street would defeat by the resultant congestion the end desired, but it should, however, be accommodated by bringing it to a point as nearby as other considerations will permit.

Passenger Transportation Considerations: This bridge is planned to handle both vehicular and passenger traffic. Both classes of travel must be considered and provided for in its location and design. The needs of the vehicle drivers for relief from the delays incident to ferry travel are no greater than those of the present hundred thousand daily passengers for means of conveyance that will bear them comfortably, quickly and safely to their destination. The Spring Garden location would not fit into the present system of passenger transportation in Philadelphia, nor into its logical and practicable future development. To be landed far from their desired destination, or to be so detoured from their natural line of travel, would simply force the great majority to continue the use of the ferries.

On the New Jersey side, the river crossing at this site is $\frac{5}{8}$ mile north of the present main line of transportation. It would be necessary to traverse this distance by surface cars. On the Philadelphia side the great majority would in this case have to pay an additional fare for an average of $\frac{3}{4}$ mile ride on the surface cars through the crowded north and south streets, between the bridge end and their destination. Such a roundabout route would take at least ten minutes more than the present one across the ferries and at the same, or greater cost. Even if this surface car transportation were entirely satisfactory, it could not be counted on alone to carry the crowds that will wish to cross the river except for a very few years after completion of the bridge.

All our plans for passenger transportation have taken for granted that as soon as the requirements of the traffic are well established and as quickly as the new rapid transit facilities are provided in Philadelphia it would be desired to connect them with the bridge route so as to permit high speed transit to and from Camden. This is the ultimate benefit that is to be given the interurban passengers by the construction of the bridge—the really marked step in advance over the present day facilities. No site begins to meet the needs of the situation unless it affords an opportunity for such development. The Spring Garden location terminus

does not. There is no planned or probable extension of the Philadelphia trunk subway system that would be within five-eighths of a mile of the end of the bridge. There is nothing in the Philadelphia transit situation to justify the expectation that a subway section of that length would be built from the authorized lines to pick up the bridge passengers, through a region offering little other traffic.

High speed transit across the river, with direct connections to the city systems, would not be practicable at the Spring Garden location.

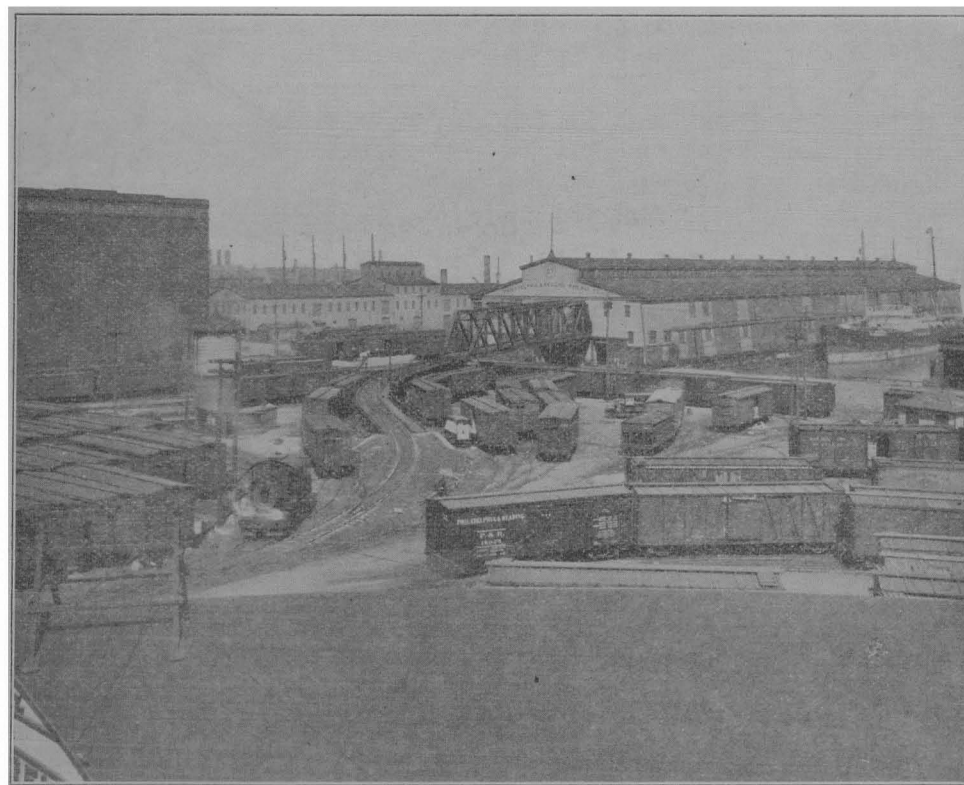
Vehicular Traffic Considerations: An analysis of the nature of the vehicular traffic to be handled also shows the undesirability of the Spring Garden site. Of the present average daily traffic over the ferries only 24% comes from or goes to regions north of Spring Garden Street. Most of the remaining 76% would be obliged to make at least a mile of detour out of its natural route in order to use the Spring Garden bridge. Even for the traffic coming down Broad Street from the north, Camden County Court House is nearly one-sixth mile further distant by Spring Garden and State Streets than by Ridge Avenue and the recommended bridge location.

The chief claim of the Spring Garden Street site for consideration is the existing wide street, which is at the present time largely unused. This would take care of the needs of traffic to and from the west. Fully 50% of the travel, though, would be to and from the south, and to handle it a north and south street would have to be widened. It has been suggested that Seventh Street be used for this and that the widening extend from Passyunk Avenue on the south to Germantown Avenue on the north. This would provide a through route for the relief of Broad Street in addition to serving the needs of the bridge. While this widening would give access for vehicles to and from the bridge at the Spring Garden site, the majority of them would have to make a long detour from their desired path to avail themselves of it. In Camden, if the approach should run along State Street it would be necessary to provide a wide north and south avenue similar to the one we propose, but more than twice as long, to carry the bulk of the traffic between the bridge end and the Court House. The site has the further disadvantage that access to streets south of the proposed plaza would require crossing of the Willow Street railroad tracks at grade. There would be similar crossings of the Main Street tracks in Camden if the New Jersey approach is extended out State Street.

Objections to the Spring Garden-State Street Location: It has been generally considered that a bridge on the Spring Garden Street line would be considerably less expensive than at the other sites. Our studies and investigations as to actual property values and probable damages have not borne this out. The main span cost is practically the same as that for the Franklin Square-Pearl Street bridge. It requires a somewhat longer approach on the Philadelphia side to reach Sixth Street and Spring Garden Street than to reach Franklin Square. For most of

its length this approach would pass through relatively low priced property, but the Philadelphia anchorage would have to be placed in the Noble Street yard of the Philadelphia and Reading Railroad. This is an important terminal, the use of which could not be abandoned by the railroad, as it plays an important part in the transportation facilities of the Port of Philadelphia. Its relocation would involve a large expenditure by the railroad if the present yards were taken for bridge purposes. On the other side of the river, in order to secure a minimum length of river span and to secure a Camden approach parallel to State Street, it is necessary to place the main pier of the bridge in front of the terminal of the Shackamaxon and Vine Street ferries. This would seriously interfere with the use of these slips and, together with the location of the anchorage further back on the property, would cause a considerable damage to the Pennsylvania Railroad Co.

We have given consideration to a variation in the New Jersey end of the Spring Garden St. line which would bring that approach into Camden along the south side of the railroad in Main Street to a plaza at about



The Noble Street Yard of the Philadelphia and Reading Railway. The Spring Garden Location for the Bridge would require its abandonment.

the site recommended for the Franklin Square-Pearl St. line. This approach would offer more convenient access to the bridge in Camden than the State St. landing, but the change does not remove the basic objections to the Spring Garden St. location.

For the foregoing reasons we consider that this site is much less favorable for the bridge than the recommended Franklin Square-Pearl Street location.

THE FRANKLIN SQUARE-PEARL STREET SITE

This site occupies middle ground between the extremes of the Washington Square line on the south and the Spring Garden Street line on the north; at the same time its advantages are in large part such as are not to be found elsewhere.

All our special studies of the cross-river traffic have served to emphasize the convenience of this site to the majority of those who will use the bridge. The facts disclosed in the test borings and the development of the design have shown likewise its advantage in economy of construction.

Convenience to Vehicular Traffic: For the reasons just enumerated in our discussion of the Spring Garden Street site, the bridge approach should be placed as near to Market Street as is possible without adding to the burden of the congested streets south of Race Street, and to the north rather than to the south of the central business district. *The Franklin Square plaza will be as close to the center of origin and destination of vehicular traffic at 10th and Filbert Streets as it is practicable to locate an approach.* It would draw 32% of its vehicular traffic from the north and 33% from the narrow strip immediately south (Race, Arch and Market Streets). The other 35% of the vehicles have been found to be for or from regions south of Market Street.

The Franklin Square-Pearl Street line will convey traffic to its desired destination with economy and directness.

How well the Franklin Square plaza fits into the highway system of Philadelphia is apparent on examining the map of main traffic arteries (Plate II). A distribution is possible by direct routes to all parts of the city and over its boundaries. The routes are ample as to their number and the direction they take. The widening of some of them would be essential even if the bridge had not been planned. The two diagrams, Figs. 1 and 2 show how the Franklin Square approach fits into either

the enlarged Traffic Circuit recommended by the Bureau of Surveys of Philadelphia, or into the widened Sixth Street, Vine Street and Ridge Avenue which we propose in case the Traffic Circuit does not materialize before the bridge is opened.

The recommended widening of Vine Street from Sixth Street to Broad Street would furnish an avenue of sufficient width to care not only for the future increase in travel on that thoroughfare but would also provide a highway through which the traffic from the bridge could be distributed to and along Broad and other north and south streets. Its extension to the Parkway and beyond by a new bridge crossing the Schuylkill to Powelton Avenue would furnish opportunities for connections with main thoroughfares leading to important districts outside the city without bringing the bridge traffic through the central business section.

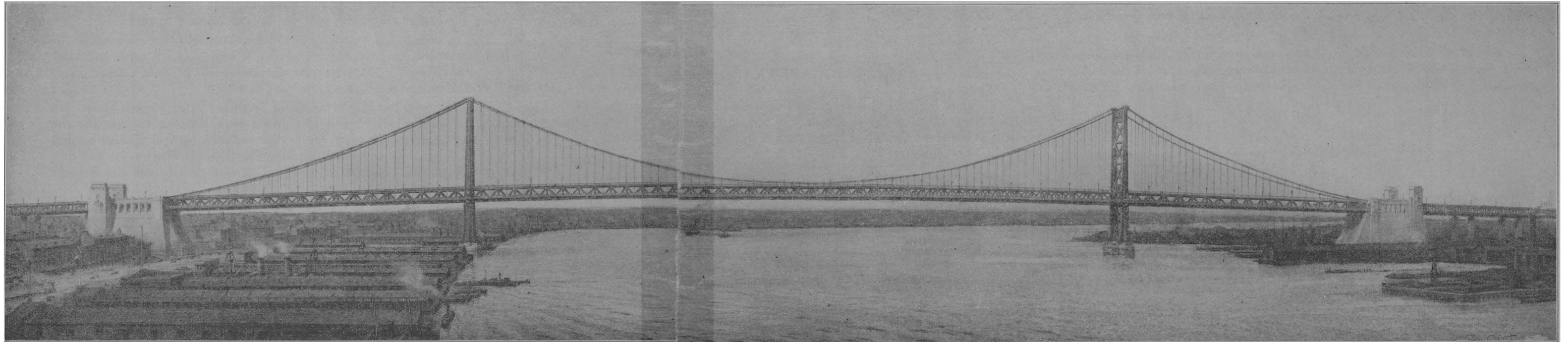
The recommended widening of Ridge Avenue from Vine Street to Broad Street is a long needed improvement and would furnish an outlet from the widened Vine Street to the northwest and provide a more direct route to the bridge for traffic from that direction.

The proposed increase in width of Sixth Street or Eighth Street (as may be determined later) will give street area sufficient to care for the distribution of the traffic from the bridge and also furnish a much needed avenue leading north and south through the business districts of the city, and give opportunity for making connections with present and future main thoroughfares leading to the outlying districts.

On the New Jersey side of the river the recommended approach will give a distribution of vehicular traffic at a plaza convenient to the actual focusing point of the New Jersey highways. It will not involve forcing the through traffic along Camden's business streets or in a long detour. From the plaza at Sixth and Penn Streets travel to the northeast would be out Seventh Street and over the State Street bridge until such time as its growth might warrant the creation of a new diagonal street (shown in dotted lines on Figs. 1 and 2). The southern and eastern New Jersey travel, which will always be the heaviest, has access to Federal Street, Haddon Avenue and Broadway by direct route, crossing as quickly as possible through Camden's business section.

The suburban route map, Plate III, shows how directly the main thoroughfares from outlying Pennsylvania and New Jersey districts lead to the streets near each terminus of the bridge.

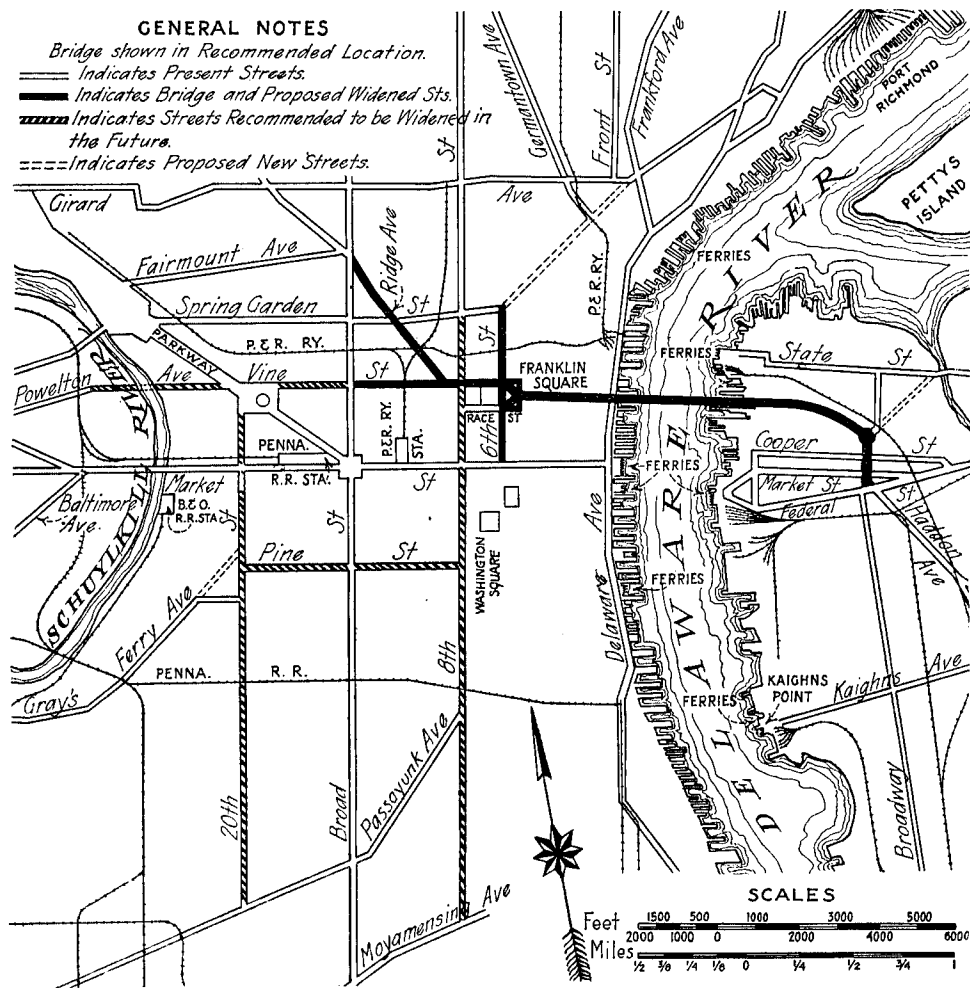
Conveniences for Passenger Transportation: The Franklin Square terminus is adapted to both the present day transportation systems in Philadelphia and to the planned and authorized extensions of rapid transit. By constructing a short section of subway the future Arch-Eighth-Locust delivery loop could be connected to the underground station at the bridge plaza, or rapid transit trains be sent direct from all parts of Philadelphia over the bridge into Camden. The plaza at Sixth and Race Streets will be, moreover, within convenient walking distance of Philadelphia's shopping and business district.



Longer than any Existing Suspension Bridge in the World—The Main Span Across the Delaware from Philadelphia to Camden

In Camden, the proposed loop line of bridge surface cars will make connections with the present New Jersey traction system (and through it with the Philadelphia and Reading Railway) and the Pennsylvania Railroad at its Broadway station. A later development of elevated high speed tracks through Camden would give rapid transit from Camden to all parts of Philadelphia.

Conditions Affecting Construction and Cost: We have stated that the cost of a bridge is directly affected, when considered at one site in comparison with another, by the differences in foundation conditions, in the required length of span and approaches, and in the disturbance to such structures and business as are located in the section traversed. *The Franklin Square-Pearl Street line demonstrates its fitness by excelling the two other sites in every one of these particulars.*



Our test borings gave us the unquestioned evidence of suitable foundations (actual rock cores removed) at a higher average elevation at the two main piers on this line than on either of the others. This means that the foundation construction will be sure and safe and at a minimum cost.

Triangulation across the river has established that the main span of the bridge on this location, which runs almost at right angles to the pierhead lines, would be the shortest of all those considered. In long span bridge construction every foot increase in length means a disproportionate increase in cost.

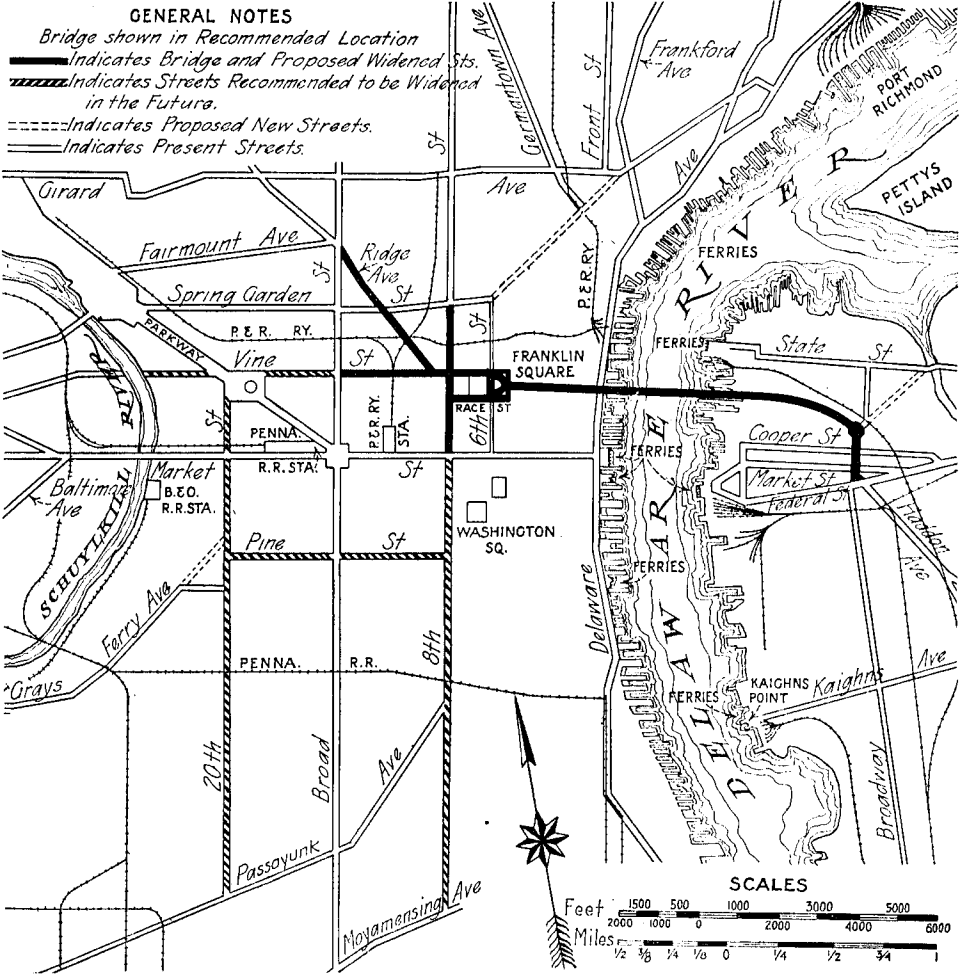
Fifth Street between Race and Vine Streets happens to be a high point in that section of Philadelphia. This difference of about five feet from the elevations of Fifth Street at the other terminals considered, means a decrease of about 150 feet in length of approach. It made it possible to reach the ground level on an easy grade without encroaching on Franklin Square. It also made the construction of an underground passenger station much easier.

Between Delaware Avenue and Sixth Street the bridge site does not take any properties of outstanding value. They are in large part the typical dwelling houses and stores built too long ago to be in good condition and not long enough ago to have historic value. A few business and factory buildings are of better type. Cost of their acquirement can be measured entirely in money terms as it has been in our estimate—their removal does not deprive the city of any structure of note. Only one structure with known historical and sentimental value, St. Georges M. E. Church, comes within the area proposed to be acquired. This venerable edifice is on the site of one of the roadways that we advise should be cut through to the river parallel to the bridge. In this case we desire to recommend to the Commission that the structure be removed to a new location and placed in a setting worthy of its honorable record. We have submitted the proposition to a firm specializing in such work and they advise that they can move this church without the slightest damage to it.

In Camden no properties of relatively great or historic value are interfered with.

On the Philadelphia side this site will cause the least disturbance of any of the plans to the water front development. Pier 11 North, owned by the City of Philadelphia, the outer end of which will be taken, is a wooden structure of the older type and the business transacted upon it can be readily accommodated on nearby piers. The City is about to erect two modern piers a short distance to the south of this one, which will be available.

On the New Jersey side of the river the pier affected by the location of the anchorage is an old wooden bulkhead-and-fill structure which does not extend to the pier head line.



The location entails no damage to important railroad facilities, as do both of the other two. Work on this line would not involve any interference with the ferries nor in any way disturb regions of congested traffic.

It was through such a comparison as this, point by point, with the other locations, that we determined that a bridge on the Franklin Square-Pearl Street line would excel in convenience of use, in economy of construction and in its least disturbance to existing structures and important facilities. We believe it to be the proper site for the bridge over the Delaware River between Philadelphia and Camden.

PART TWO

HISTORICAL

The earliest record of a definite project to construct a bridge across the Delaware River between Philadelphia and Camden was in 1818 when an application was made to the Legislature of New Jersey and later to the Legislature of Pennsylvania to build a bridge from the Camden shore to Windmill (Smith's) Island, a distance of 2200 feet, leaving the remaining distance to the Pennsylvania shore to be covered by a ferry. The plans for this bridge bore the names of the projectors and designers, Farrand and Sharpe.

There does not appear to have been any organized effort to secure a bridge over the Delaware River until the Legislature of New Jersey by Act approved the 17th day of April, 1914, provided for the appointment of a Commission with "power to construct one or more bridges or tunnels under or over a navigable stream or river which is a boundary of the state." This Commission was not fully organized until 1916. It retained the services of Waddell and Son, Consulting Engineers, to make a study and report on the Delaware River crossing.

The Commission presented its report in 1918, suggesting a bridge at the Arch-Cooper Street location, and advised against the use of a tunnel.

On December 17, 1914, Councils of the City of Philadelphia by resolution requested the Chief Engineer of the Bureau of Surveys to report if the plan to erect a bridge over the Delaware River connecting Philadelphia, Pennsylvania, with Camden, New Jersey would be feasible. On December 29, 1915, George S. Webster, Chief Engineer, Bureau of Surveys, reported that the Philadelphia-Camden Bridge, as an engineering matter, was perfectly feasible, and recommended a high level type of bridge with no piers in the river between pierhead lines, and suggested that the bridge be located from Race and Fifth Streets, Philadelphia to Linden and Sixth Streets, Camden.

By Ordinance of the Councils of Philadelphia, approved February 18, 1916, the Directors of the Departments of Public Works, City Transit and Wharves, Docks and Ferries, were authorized to act as a Joint Commission to investigate and report upon the engineering and financial feasibility of constructing a bridge connecting Philadelphia and Camden. This Commission was superseded by a Pennsylvania State Commission of three members authorized by Act, approved July 25, 1917.

By Acts of the Legislature of New Jersey in 1918, the Interstate Bridge and Tunnel Commission was created as a new body and authorized

to proceed with the construction of tunnels and bridges as extensions of the State highway system. This Commission joined with the Pennsylvania Commission and engaged Dr. Warren P. Laird, Consulting Architect, to make studies and report upon a location for a bridge over the Delaware River. He reported on November 30, 1918 and recommended what is known as the Washington Square-Federal Street site.

In 1919 the Legislatures of Pennsylvania and New Jersey passed uniform laws, creating the present Delaware River Bridge Joint Commission, with full power and authority to proceed with the construction of the bridge. This Commission on September 24, 1920 engaged the present Board of Engineers, for the purpose of preparing this report.

LIMITATIONS ON LOCATION

Geographical: The course of the Delaware River and the natural developments of the centers of business of Philadelphia and Camden define a rather broad zone inside of which must come all suggested locations for the bridge. To the north of Green Street the sharp swing of the river toward the East around Coopers Point on the New Jersey shore interposes a natural limit. To the south of the main business centers (below South Street) the increase of width of river channel makes the construction more costly and the greater inconvenience to inter-city traffic render these locations less desirable. No locations outside of these limits have been considered in this report.

Legal: The respective acts of Legislature of the States of Pennsylvania and New Jersey authorizing the formation of the Delaware River Bridge Joint Commission contain no restrictions as to the location which it is empowered to select except that the bridge shall connect the city of Philadelphia with the city of Camden.

The limits of locations as defined by Congress in granting its authority by Act of February 15, 1921 for the construction of the bridge, were Green Street, Philadelphia on the north and South Street on the south to points approximately opposite in Camden. A bridge within these bounds will be legal when its plans have the final approval of the War Department.

Within the zone thus fixed by Congress there are no natural features on either side of the river that obviously determine the proper location. A free hand is therefore given to the selection of the most advantageous site.

PRELIMINARY PROCEDURE

Organization: The Board of Engineers, following its appointment by your Joint Commission met on September 29th, 1920 and immediately proceeded to outline the work entrusted to it. Upon your approval of our budget covering the expense of carrying on the necessary investigations a complete engineering staff was organized and suitable offices rented. Mr. Leon S. Moisseiff was retained as Consulting Designing Engineer. Mr. Paul P. Cret was appointed Architect, with Mr. Arnold W. Brunner, as Consulting Architect. Mr. Clement E. Chase was appointed Principal Assistant Engineer and Mr. E. B. Bergendahl, Chief Draftsman and Assistant Engineer. Special assistants were from time to time engaged for taking the traffic counts. The work of making investigations and preliminary plans was actively begun on December 1st, 1920.

Information to be gathered: Some of the principal facts that it was necessary to assemble, to guide us in the selection of the proper site to recommend for the bridge were:

1. An accurate map of the zone of possible locations.
2. Information as to under-ground conditions.
3. What limitations as to span and clearance would be imposed by the Federal government.
4. The nature and path of the present traffic.
5. The extent and requirements of the traffic of the future.
6. Possibility of changes in the City Plan to handle this future bridge traffic.
7. The cost of property and of structure at each of the alternative sites.

Most of these topics cover investigations that have extended over several months in order to secure as complete and accurate information as possible.

SURVEYING AND MAPPING

Existing large scale maps, although quite complete for each city in itself, were found to be not accurately tied together across the river. One of our first steps was to secure the information upon which an accurate inter-city map could be constructed. By triangulation across the river the distance between pierhead lines and the relation and inclination of the

streets of one city to those of the other were established. The easterly and westerly streets of Camden are not laid out in line with corresponding Philadelphia streets, nor are they parallel to them. The inclination of the streets on one side of the river with those on the other is nearly five degrees.

The elevation of bench marks on the two sides of the river were checked with each other so as to give all elevations in terms of the city datum of Philadelphia, which is 2.25 feet above mean high tide in the Delaware. The Philadelphia datum has been used as zero in our drawings and plans.

After this coördination of information we were able to proceed with the preparation of our own maps, upon which the suggested locations of the bridges were plotted for study. From these we determined the main span lengths, the required length for approaches, the alterations that must be made in the existing street systems, and the property that must be acquired to make room for the structure and the street changes. Separate property maps (Plates XVIII and XIX) have been prepared to show the registered owners of property in the strips through which approaches would pass, and the portion of each parcel that would be taken.

TEST BORINGS

From what is known of the geological formation of the Philadelphia-Camden district, it has always been assumed in former discussions of the bridge project that rock would be found at all sites at depths practicable for pneumatic foundations. In order to have definite and trustworthy information on subsurface conditions test borings were made under our direction along three lines across the river. These were selected so that information secured from them would cover, by interpolation, all the sites under study.

That there should be no doubt as to the elevation and quality of the bed rock, the specifications called for the extension of the drilled holes into rock by core boring whenever considered advisable. The contractors, Ridpath and Potter of Philadelphia, drilled 15 completed holes along the three designated lines. Six of these were borings in the river at the pier head lines. Three on the Philadelphia side were made from the ends of piers, but for the corresponding holes on the Camden side a floating equipment was required. Due to the ice in the river, fog and bad weather, this work was carried on with considerable difficulty.

Samples of the material penetrated by the casing were taken, at five-foot intervals or oftener, and have been carefully classified, labeled and preserved. The cores have been preserved and arranged so as to show the strata of the bed rock penetrated and are available for future reference.

As previously known in a general way of local conditions, rock was found to dip to the east and to the south. In the main it is a mica gneiss—familiar in its land out crops in Philadelphia as the Wissahickon Gneiss.

This rock is much folded and very irregular in its formation and elevation. It is shot through with dikes of pegmatite, a coarse grained granitic rock. This rock is a very satisfactory material upon which to found the main piers of the bridge. Its identification removes the possibility of soft, unreliable strata existing below it as might be the case with other formations. Overlying the sound gneiss there is a zone of disintergrated rock—varying in thickness from five feet to 35 feet in extreme cases. This is a condition similar to that found in neighboring quarries, and in general where the rock is softened through past ages, had not been removed by erosion.

The distance below the main high water at which the first core samples of rock could be recovered, at each site, were as follows:

Site	Philadelphia Main Pier	Camden Main Pier
Spring Garden-State St.	69.5	111.4
Franklin Square-Pearl St. . . .	86.7	91.6
Washington Square-Federal St.	111.8	104.5

The conditions at each hole are more fully set forth on Plate VII.

The depth at which the first cores were recovered at the west pier site of the Washington Square-Federal Street line and at the east pier site of the Spring Garden-State Street line is near the practicable limit of pneumatic foundation work. Between 110 and 115 feet depth, the men can only work one half hour at a time, due to the heavy air pressures required, and the risk to life and the cost are enormously increased over those at more moderate depths.

RIVER CHANNEL CLEARANCE

At the outset of our study of the problem of location it was evident that it could not be carried to any definite conclusion until the uncertainty concerning Federal requirements as to channel and clearance for a bridge over the Delaware should be removed. Under the usual conditions precedent to the design of a bridge, where the location is fixed within narrow limits, the War Department makes its ruling only after the submission of definite plans, showing clearances and the location of piers with respect to the channel. In the case of the Delaware River Bridge, where information as to required clearance was needed in order to decide on location and design, special permission for a preliminary ruling was at your direction sought and obtained from the Chief of Engineers, U. S. Army. Major L. E. Lyon, U. S. Engineer Officer for this district, held a public hearing in Philadelphia on February 15, 1921, for the purpose of considering the clear height and length of span that the War Department should require. At this hearing we urged that the height of the lowest part of the bridge above mean high water be set at 135 feet for the central 800 feet of the span. It was explained that the proposed clearance would afford under extreme temperature and load conditions, a clear head room of 137 feet

at high tide for a distance of 300 feet at the center of the span and that at low tide there would be a clearance of 142 feet 6 inches for the same width. Under average conditions there would be 145 feet clearance for this central 30 feet at each low tide.

In the brief submitted to Major Lyon at this hearing we stated in support of the request for approval of this clearance:

“That the bridges over the East River in New York City are 135 feet (133 feet in the case of the Brooklyn Bridge) above mean high tide;

That merchant and naval vessels are already designed so as to pass the Brooklyn Bridge when necessary;

That the Kiel Canal was built with a clearance of 138 feet between fixed bridges and fixed water level, and that the Manchester Canal, built at a cost of \$84,000,000 to bring ocean trade to the City of Manchester, has a clearance between fixed bridges and water level of 74’ 6”;

that the Hawthorne Avenue bridge over the Willamette River in the important Pacific Coast port of Portland, Oregon, has a clearance above mean high water with vertical lift draw raised of 135 feet;

That the cost of construction of this bridge would be rapidly increased with each foot of added height;

That the cost of raising traffic each foot above the minimum required to pass river traffic will impose a perpetual, if intangible, tax on the community;

That there is no vessel among the 13,000,000 tons of ships built by the U. S. Shipping Board but could pass under such a bridge;

That there is no war vessel of the U. S. Navy but that could pass under this bridge, with top masts housed;

That of 710 steamships actually entering the Port of Philadelphia since the appointment of this Board but two vessels exceeded 135 feet in height and both of these could pass under the bridge in the central 300 feet of the span;

That the only vessels entering the Port of Philadelphia since October 1, 1920, and which could not have passed such a bridge without any preparation were not over nine sailing vessels and these were but two-tenths of 1 per cent of the tonnage entering the Port; in many cases actually docked south of South Street; could all have passed after housing their topmasts; are accustomed to doing that very thing in passing the Brooklyn Bridge; and represent a fast disappearing class of ship;

That no vessels have been constructed or are under construction in the United States yards, up to liners of 20,000 tons displacement, but could pass under this bridge;

That the only vessels that could not pass under such a bridge, except for a few freak ships, are the largest passenger

liners of foreign construction and these could not, in many cases even be turned around in the upper river; would also require longer docks than are available in that part of the river; could find ample docking room below the proposed bridge sites; have top masts higher, in many cases, than is found ample in American practice; and could, if necessary, arrange to house, or telescope their top masts.

That sixty per cent of the port traffic of steam and sailing ships docks below the site suggested at Walnut Street and eighty per cent below the sites suggested near Race or Callowhill Street;

That practical shipping men, consulted by the Board, have stated as their opinion that this clearance will be ample for a structure at the proposed sites;

That no practicable greater height would pass all vessels, nor give benefits to navigation in any way commensurate with the increased cost of the bridge and the increased expense of operating over it."

The hearing was largely attended by representatives of civic associations and public bodies, port and shipping authorities and other interested parties. All but one of those speaking endorsed the clearance proposed.

The decision of the Chief of Engineers, U. S. Army was announced by letter from Major Lyon on March 30, 1921, in which it was stated that "a bridge with no piers between pier head lines, and with a clearance of 135 feet at mean high water for a width of 800 feet extending 400 feet on either side of the center of the span, is permissible over the Delaware River between Philadelphia, Pa., and Camden, N. J.," and that plans would be approved if submitted in accordance with those dimensions.

Following this ruling we are able to proceed with the studies of approaches, their lengths and grades. Its effect in the case of the Franklin Square location was to permit the planning of an adequate plaza for distribution of traffic without invading the Square itself, and still keep the gradients of the bridge and its approaches within 3½%.

The ruling of the Chief of Engineers that no piers should be built in the river beyond the harbor lines confirmed what previously had been generally assumed, that the crossing must be made by a single long span from pier head line to pier head line. The corresponding lengths of main spans at the various locations are, respectively, Lombard Street-Clinton Street 1861 feet, Washington Square-Federal Street 1815 feet, Market Street-Market Street 1784 feet, Franklin Square-Pearl Street 1750 feet and Spring Garden Street-State Street 1758 feet.

STUDIES OF PRESENT DAY TRAFFIC

A highway bridge is in the most convenient location when, following the principle of the greatest good to the greatest number, it is placed in the path that the majority would wish to take. Such a choice need be

subject only to the further restrictions of practicability, reasonableness of cost and adaptability to the probable needs of the future.

The division of the Delaware River traffic between the different ferries would indicate that the Market Street-Federal Street ferry route comes nearest to this path of maximum convenience of the cross river routes now in use. The 1920 ferry statistics show the following:

Ferry	Vehicles	Per Cent	Passengers	Per Cent
Shackamaxon St. & Cooper's Point	177,655	7	545,293	1
Vine St. & Cooper's Point	161,496	6	813,007	2
Market St. & Federal St.	1,462,795	61	36,879,998	77
Philadelphia & Reading Ry. Ferries	622,900	26	9,483,966	20
	2,424,846	100	47,722,264	100

The Market Street route carries over half the vehicles and three-quarters of the passengers that cross the river. Into the channel established by this route and that of the connecting transportation lines the paths of the individual users are now forced. How this route would compare in convenience with possible bridge lines to the north or to the south, or how they would compare with each other, can only be determined by an analysis of the actual conditions and requirements.

The routes of the average users,—teamsters, autoist or truck driver, car rider or pedestrian, must be traced and the most convenient line to meet their combined needs determined upon. Once information on sufficient individual cases is in hand, it is possible, through simple principles of mechanics, to select the point from which these average users start and the point to or through which they desire to go.

One of our first problems was the collection of this data. Vehicles: Vehicular travel between the two States naturally falls into four principal classes:

- 1st: The ordinary daily inter-city flow of commercial, industrial and passenger automobiles and horsedrawn vehicles;
- 2nd: The trucking from the New Jersey farms to the Philadelphia markets;
- 3rd: The touring from Philadelphia and surrounding territory to New Jersey coast resorts and,
- 4th: The long distance inter-state motor trucking and pleasure touring.

Little information existed as to the character and amount of the first class. The second and third are seasonal in nature and could not be fully observed during the period of preparation of this report. Fortunately a study had been made in 1918 by the New Jersey State Department of Agriculture of the truck farm traffic, which was presented in the 1919 report of the Delaware River Bridge and Tunnel Commission of Pennsylvania. The amount and route of the second class were thus available, as the New Jersey Bureau of Markets advised that this data would hold

good for present conditions. Enough is known of the routes travelled by those bound to the seashore to enable any of the bridge sites to be tested for convenience to their use. The fourth classification of travel has only begun its development across the Delaware at this point, and will be little affected by the exact location of the crossing, provided proper connection be supplied to the state highway systems on both sides of the river.

Vehicular Traffic Census: It was possible for us to take an actual census of only the first and fourth of these classes. Fortunately, they comprise fully 80% of the total traffic at present carried by the ferries.

The count was taken during three representative weekdays of December, 1920. Observers were stationed in relays on all of the ferry boats of the six lines in service between Philadelphia and New Jersey points. Each driver was asked what town, district or street intersection he had started from and, similarly, what his destination was. The observer also recorded the classification of the vehicle (i. e. whether team, passenger, automobile or truck) and the ferry route and time. During the three days, answers were secured from the drivers of 16,269 vehicles.

In analyzing the information thus secured, the business districts on both sides of the river, inside the permissible north and south limits of

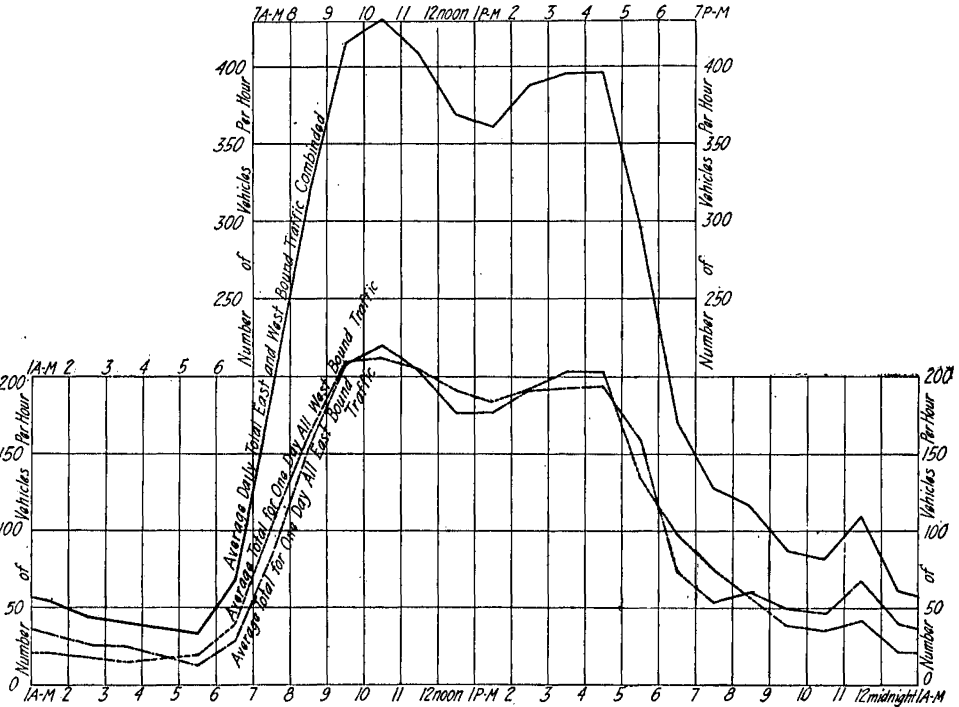


FIG. 3—DAILY VEHICULAR TRAFFIC OVER ALL THE DELAWARE RIVER FERRIES, SHOWING AVERAGE NUMBER CROSSING IN EACH HOUR. TRAFFIC COUNT, DECEMBER, 1920.

bridge location, were divided into sections or zones. The origin and destination given on each card were then assigned to their proper zones or

to the highways used into or out of the business district. This data was summarized and tabulated. By analyzing these results it was possible to establish the centers of origins and destinations of vehicular traffic on each side of the river. In Philadelphia this point is located at the intersection of 10th and Filbert Streets, one-half square north of Market Street. In Camden the corresponding point is at 7th and Stevens Streets, two blocks south of Federal Street. A straight line joining these two centers represents the theoretical route which would be shortest for the average vehicle.

It was also possible to determine the relative distance that would be travelled by an average vehicle proceeding from the Philadelphia center to the Camden center over five possible bridge lines. Market Street-Market Street was the shortest with 2.54 miles, Washington Square-Federal Street next with 2.65 miles, Franklin Square third with 2.9 miles, Lombard Street-Clinton Street fourth with 3.0 miles and Spring Garden-State Street the longest with 3.6 miles.

Produce from New Jersey: The truck farm traffic from New Jersey, which is at its height in the five months from June to October, was shown by previous studies to amount to about 10% of the total carried by the ferries. It goes to one or the other of the two commission house districts in Philadelphia. Of these, Dock Street gets 85% to 90%, with the remainder going largely to Callowhill Street.

The majority of those handling this trucking to the Philadelphia market would favor a site south of Market Street. Their claims deserve careful consideration, but not to the extent of setting aside the interests of a majority of the prospective bridge users. The center of traffic as established by our vehicular census was for a season when this produce movement was at about one-eighth of its maximum volume, but because of its small percentage of the total traffic that center would not be shifted south of Market Street by the inclusion of the peak months figures for farm shipments. The effect of the Dock Street traffic, moreover, would be offset by the undoubted northerly origin of the summertime travel of passenger automobiles to the New Jersey shore resorts.

Passenger Automobiles: No quantitative statistics are available as to the amount and distribution of the summer season passenger automobile travel to New Jersey points from the territory west of the Delaware. Its volume is considerable in the peak months and would be greatly increased by the inducement offered by the presence of a bridge over the river. It is the opinion of officials of the automobile clubs that the greatest part of this does come and will continue to come from the regions north of Market Street. This follows logically from the distribution of the residential districts and the outlying suburbs of Philadelphia. The majority of this class of users of a bridge would be better served by a location north of Market Street that would not require them to cross the congestion of Market and Chestnut Streets. They would find a shorter route by a bridge on the Franklin Square-Pearl Street line than by one on the Spring Garden-State Street location. The distance from points on North Broad Street to Camden Court House is a sixth of a mile less

by way of Ridge Avenue, Vine Street, the Franklin Square and the Pearl St. approaches than by Spring Garden Street and State Street and down Sixth Street.

Passenger Traffic: The record of passengers transported by the ferries shows a striking increase from year to year. In 1900 it was approximately 16,000,000; in 1910, 27,462,109; and in 1920, 47,722,264. Of the present total, somewhat over three-quarters are carried by the Market Street ferries. The Pennsylvania Railroad Company advises that approximately one-third of the people it ferries over the river are rail passengers, coming from or going to its trains. Of this one-third, about 70% are commuters, coming from New Jersey points to work or shop in Philadelphia, and the remaining 30% are largely passengers to and from New Jersey coast resorts. The greater part of the latter class of travel is during four or five summer months.

The ferry records report as local passengers all those who do not use the ferries as part of a rail journey. These local passengers are in part residents of the outlying districts around Camden who come to the ferry terminal by the cars of the Public Service Railway of N. J., in part residents of Camden who use the same cars or walk to the ferries, and the remainder largely residents of Philadelphia, who are employed or have business to transact in Camden. The last class was in former years considered a negligible quantity. The industrial development of Camden, however, has brought about a marked increase in this class, until at the present time for each 100 people living in New Jersey and working in Philadelphia there are 40 people living in Philadelphia and working in Camden. Hourly records of traffic through an average weekday in 1920 show 4500 persons going eastbound over the Market Street Ferry between 7 and 9 A. M. and 11,500 going westward to Philadelphia.

The average daily total of passengers both ways during 1920 was 130,740, with nearly 200,000 on the maximum day. The heaviest movement occurs on important summer holidays. A count on the Market St. Ferries including Decoration Day, 1920, showed people going from Philadelphia to Camden during Saturday and Sunday and Monday morning at a fairly steady rate. The majority apparently tried to return on Monday evening, for the count was above 9,000 an hour for four hours between 6 and 10 P. M. and recorded a maximum of 13,025 in the hour from 7 to 8 P. M. The great majority of all these passengers unquestionably look forward to the date of the opening of the bridge for relief from the annoyances and delays of ferry travel. To how great an extent this expectation will be met is dependent upon the location of the bridge and the transit facilities provided.

As stated elsewhere, we recommend that a bridge shuttle service be provided for passenger transportation at the date of opening of the bridge. The Philadelphia terminus of this line should be within walking distance of the business and shopping districts and should permit of easy transfer to the important surface car routes. On the New Jersey side of the river

these tracks would make a surface loop accessible to the traction and railroad lines.

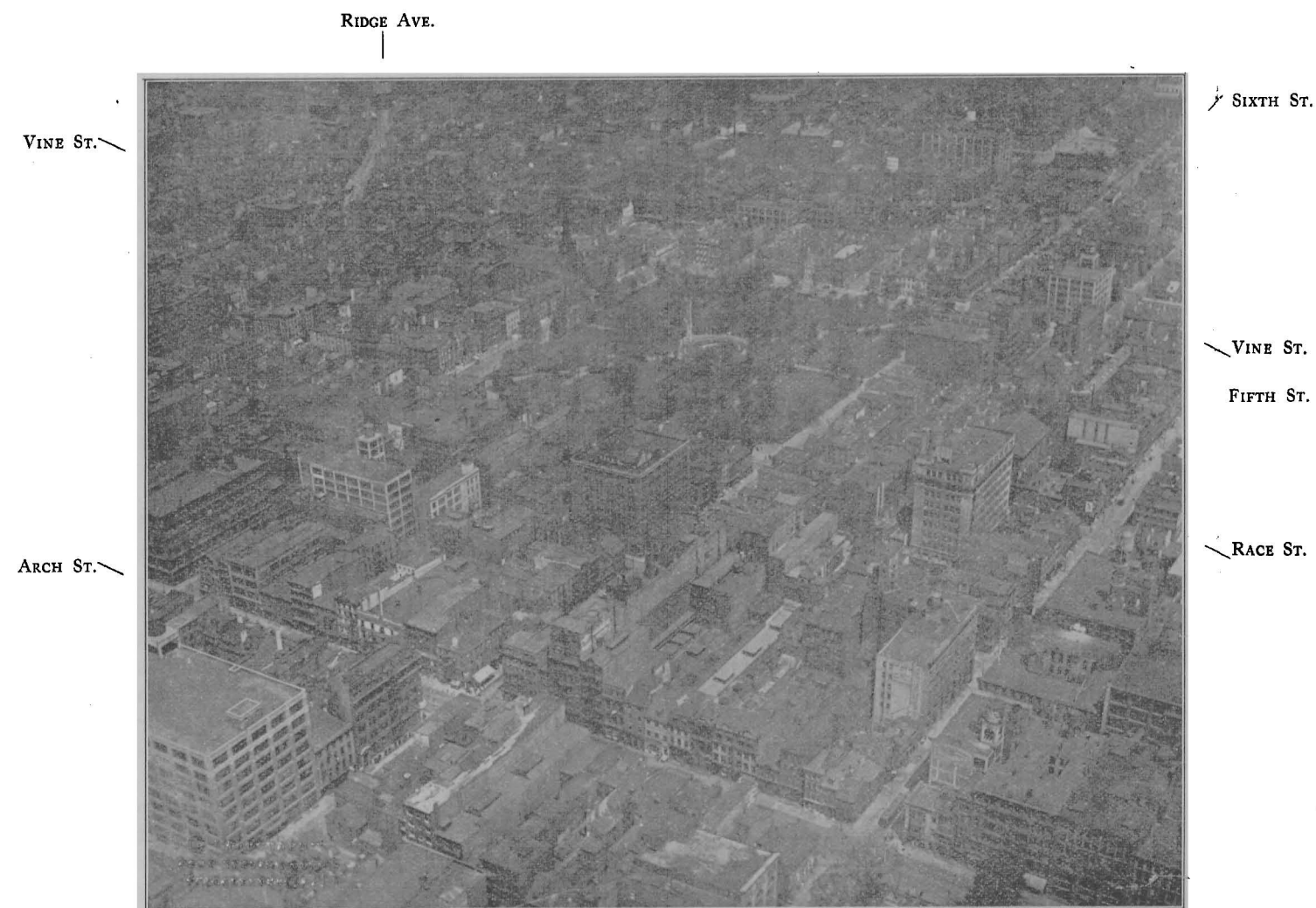
The demands of the growing interurban crowds cannot be long satisfied with only surface car transportation. We have, therefore, planned additional tracks on the bridge to accommodate rapid transit cars. In order to connect these in Philadelphia, the end of the bridge must be near existing, projected or probable portions of the Philadelphia high speed transit system. In New Jersey they would require the construction of elevated tracks to a point near the suburban and railroad transportation lines.

FUTURE TRAFFIC DEVELOPMENT

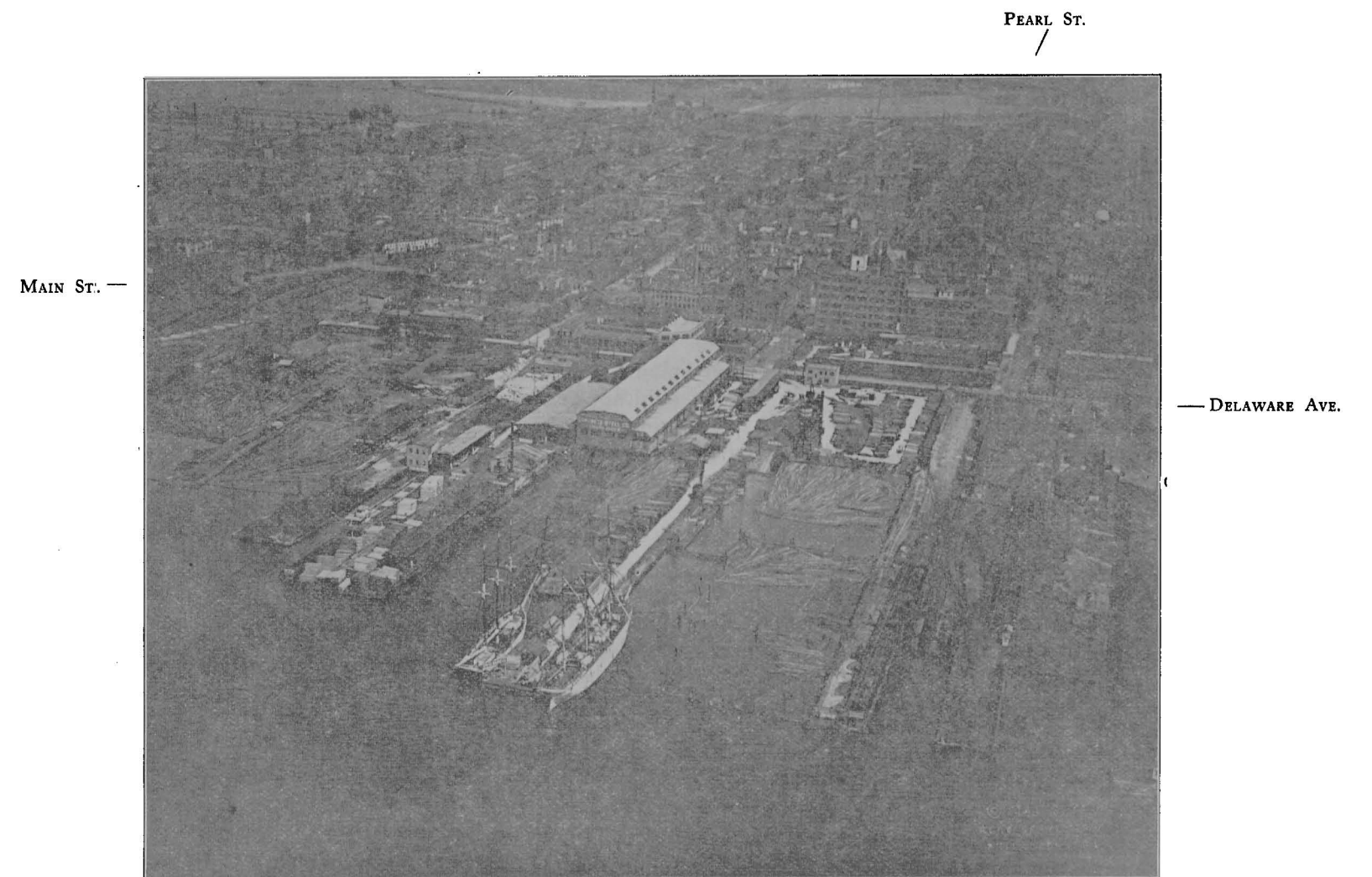
It is not alone sufficient to plan this great artery of communication to serve to the best advantage the combined traffic that now exists. It would be a short-sighted vision indeed that did not take into view the growth that will come about. There will be not only the increase from causes already in effect, which would double the vehicle total by 1929 and the passenger total by 1934, but from the acceleration to this existing rate of increase that will be furnished by the offering of the bridge route. This opens a vista that cannot be explored or measured by any mere analysis of statistics or graphical charting. The establishment of new industries near the bridge terminals in Philadelphia and Camden; the opening up of new workers' home districts outside of Camden; the facilitating of shipment of New Jersey products by all the water lines with terminals in the Port of Philadelphia; the increase in patronage of Philadelphia and Camden stores and resultant store deliveries; the long distance shipment by motor truck; all these elements will add to traffic at a rate upsetting any prediction based merely on the experience of the past. The last class of users is a very small fraction at the present, but in the future the Delaware crossing will be the hub for the interchange of shipments within a territory including Wilmington, Baltimore and Washington on the south, Harrisburg, Allentown and Bethlehem on the northwest and Newark, Jersey City and New York City on the northeast.

It is not to be expected that this growth will bring about any radical shifting of the present centers of population, industry or traffic on the Pennsylvania side of the river. We have determined these centers for an area within 15 miles of Philadelphia City Hall because from within such a radius will come the great majority of the users of the bridge. The center of area of Pennsylvania territory within a fifteen mile or greater radius of the Philadelphia end of the bridge will be north of Market Street regardless of where the bridge is located. The truth of this is self evident from inspection of any map. See Fig. 5.

The center of population in Philadelphia has been determined to be at 19th and Thompson Streets from the results of the 1920 census. It is reasonable to expect that it will never reach a lodgment south of Market



Aerial View, Looking Northwest over Franklin Square, Philadelphia



Aerial View, Looking East over Camden—Site of Camden Anchorage to Left of Center Pier

Street. When the population outside of Philadelphia in the fifteen mile radius is considered in addition to that of Philadelphia itself, the location of the center of population remains at practically the same point.

Our investigation of the location of factories and other industrial plants within the 15 mile radius has indicated the location of the industrial center on the Pennsylvania side to be at 15th and Vine Streets and on the New Jersey side to be at 3rd and Jefferson Streets.

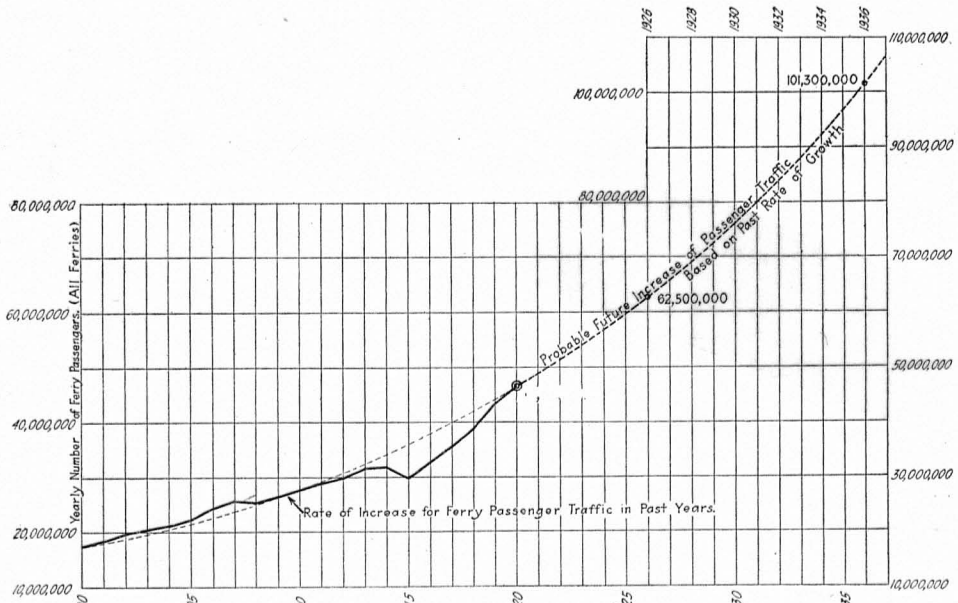


FIG. 4—YEARLY TOTALS OF PASSENGERS ON PHILADELPHIA-CAMDEN FERRIES, 1900 TO DATE, AND PROBABLE FUTURE TOTALS WITH TRAFFIC INCREASING AT SAME RATE AS FOR YEARS 1900 TO 1920.

The fact that none of these industrial districts has reached its maximum possible density of development will result in the future additions being spread fairly evenly over the entire area, holding the centers about as they are now.

The determination of such centers as those of area, population and industry is mainly of importance in its support and interpretation of actual observations as to the course of resulting traffic.

This traffic has at present a certain average center on the west side of the river and a similar one on the east. The traffic on the Pennsylvania side can now and in the future be best and most economically accommodated by the location of the terminus at Franklin Square. The Camden end of the same line, although north of the present traffic center, is well situated with respect to it. In the future it will be even more convenient.

The nearest area to the bridge end for the development of new home districts lies to the north and east of Camden. Its growth will naturally tend to increase the travel in that direction. Also, with the improvement

of the state highway parallel to and east of the Delaware, that road will become the route of much travel to and from Northern New Jersey and New York. Both these courses will tend to pull the center of traffic northward. However, the same accident of geography that places more Pennsylvania territory north of Market Street than south of it results, on the New Jersey side of the river in there being more of nearby New Jersey south of Camden's Market Street than north of it. (Fig. 5.) This distribution of the area in which traffic will largely originate will undoubtedly keep the New Jersey traffic center from ever moving north of Market Street.

The streets and entering highways that would bring present day traffic conveniently to the plazas we propose on the two sides of the river would equally well serve the future as to their direction and their distribution. Their ability to accommodate the probable volume of the traffic is

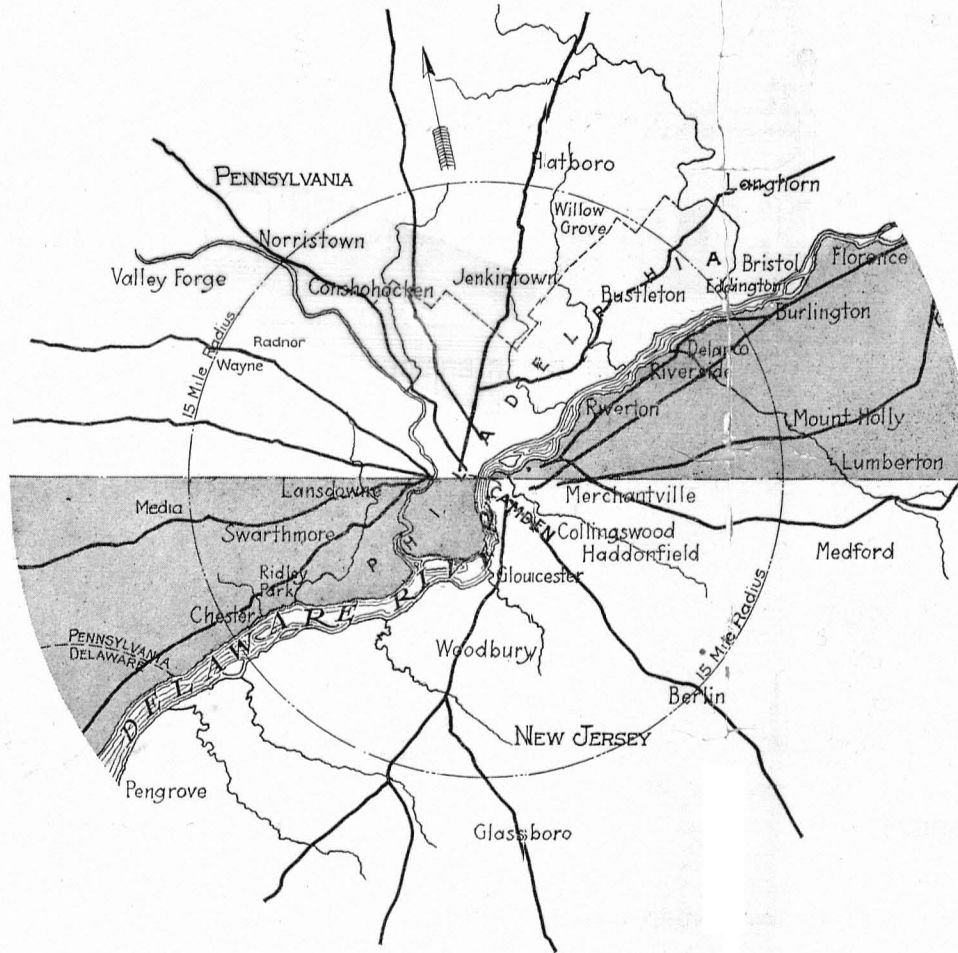


FIG. 5—EIGHTY PERCENT OF THE AREA OF PENNSYLVANIA TERRITORY WITHIN 20 MILES OF BRIDGE IS NORTH OF THE BRIDGE SITE, WHILE EIGHTY PERCENT OF THE CORRESPONDING NEW JERSEY TERRITORY LIES SOUTH OF IT.

fully as important and we have given careful thought to the possibility of increasing the width of existing approach streets and creating new ones at the various sites under study.

The average daily cross river traffic at the present time is 6500 vehicles, with an average daily peak hour of about 550 vehicles. The maximum daily total on holidays for all ferries is about 10,000 vehicles with fully 1250 vehicles seeking passage in the heaviest hour's rush.

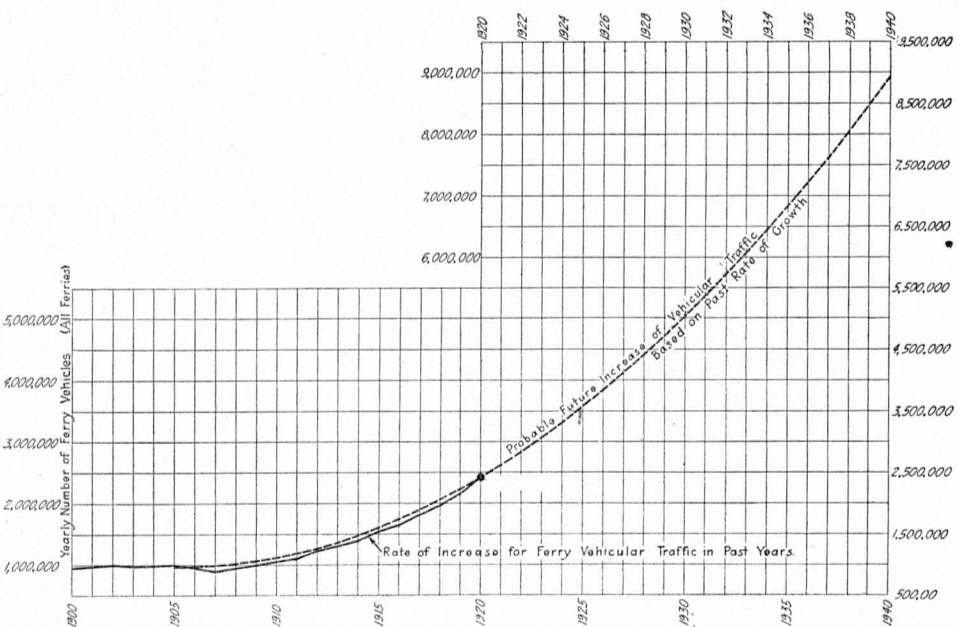


FIG. 6—YEARLY TOTALS OF VEHICLES ON PHILADELPHIA-CAMDEN FERRIES, 1900 TO DATE, AND PROBABLE FUTURE INCREASE, IF CONTINUED AT SAME RATE AS DURING 1905 TO 1920.

Assuming a probable distribution between ferries and bridge, and allowing only for the past rate of increase, there would be 2000 vehicles crossing the bridge at the maximum hour if it is opened in 1926. In 1931, five years later, if this travel grew only at the pre-bridge rate, it would furnish nearly 3000 vehicles at the maximum on holidays. The bridge would handle twice this number.

At the Philadelphia terminus this traffic would wish to go by Race and Vine Streets to the extent of about 42%. About 35% would want to move on Sixth Street just south of the bridge. The remainder would seek Sixth Street to the north and the streets paralleling the bridge approach to the Delaware River.

The ordinary city street traffic will have greatly increased in ten years, requiring in itself wider streets, without the addition of the bridge load. The way in which the bridge approaches would fit into the already suggested Traffic Circuit or the alternative widening program that we recommend for both sides of the river, is discussed later in this report.

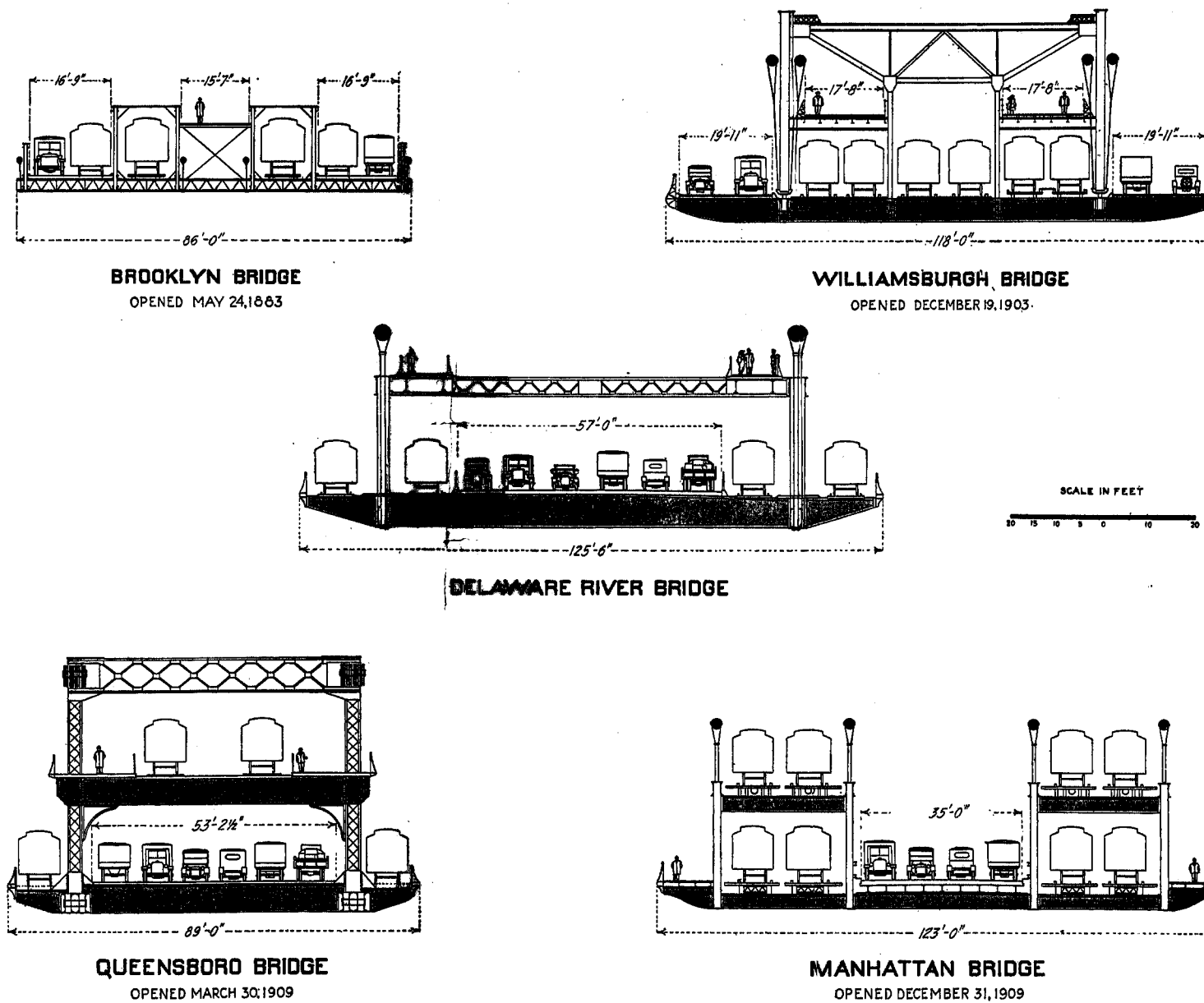


FIG. 7. SECTION OF THE **RECOMMENDED** DESIGN FOR THE BRIDGE OVER THE DELAWARE, COMPARED WITH THE **FOUR EAST RIVER** BRIDGES IN NEW YORK CITY.

DESIGN OF THE BRIDGE

The investigations and conclusions so far treated in this report have had to do with the influence upon location of those factors that are largely independent of the design adopted. No final decision could be reached on the merits of the various sites until the cost of a bridge at each location could be taken into consideration along with its convenience. Rough estimates as to this would not be sufficient, since the differences between one location and another that affect the cost of construction are in most cases relatively small, and their cumulative effect not easily approximated. It was therefore necessary to commence the design of the structure at the beginning of our work, when many factors were as yet indefinite. From time to time, as our information became more complete, corresponding revisions were made in the assumptions on which the design was based.

But little help in the actual design of the structure could be had from previous studies of the Delaware River Bridge problem. These had either been entirely devoted to convenience of location without attention to the cost factor or the designs had been based on a different character of bridge from that which commended itself to us. They agreed that the river would have to be crossed by a single span at high level and favored the suspension type of structure.

Traffic Capacity: The first step in the design was, logically, a decision as to the traffic capacity that should be given the bridge. This required a determination of the demands of the future within a reasonable period—as well as consideration of what widths of passage way experience showed to be necessary to accommodate such movements of vehicles and passengers.

Fortunately for a correct judgment in so important a matter, New York City furnishes in its four great East River bridges a working laboratory for the study of bridge roadways and their capacity. The experience with the Brooklyn Bridge has proved the inadequacy of allowing but one line of vehicular travel in each direction. On the Williamsburg bridge, provision was made for two vehicular lines each way, in separate roadways. These have not proved satisfactory, as they are easily obstructed by a single vehicle occupying the middle instead of its proper side of the narrow road. A breakdown in such a case blocks all traffic in that direction. When the Mahattan Bridge was designed, somewhat later, a single 35 foot roadway, considered wide enough for four lines of travel, two in each direction, was placed on the center line of the structure. This is considerably more popular with drivers than the Williamsburg roadways and actual observations show it to be capable of handling a greater maximum number of

vehicles per hour. It is found, however, that when carrying heavy traffic with slow vehicles confined to the outside lanes of travel, trouble is caused by the attempt of autoists in the two inside lanes to pass around those ahead of them. There is hardly enough flexibility in this arrangement to accommodate present day mixed motor and team traffic when approaching capacity load conditions. The Queensboro roadway is 53' 2½" between curbs. Originally it was intended to operate two surface car tracks in this roadway just inside the trusses. Tunnel connections to Long Island, however, have made these tracks unnecessary and the entire width of roadway is now devoted to vehicular traffic—affording six lanes of about 8' 10" each. The result is a roadway with great flexibility that is very popular with all drivers and that can handle almost double the traffic of a four lane roadway like that on the Manhattan Bridge.

We considered that not less than six lines of vehicular travel should be provided for on the bridge over the Delaware. In view of the width of motor trucks now operating we increased the width allowed for each line of travel from that furnished on the Queensboro bridge to 9' 6" and fixed the width from curb to curb on the main structure at 57 feet.

The present day cross river passenger traffic would require two lines of track for the establishment of a bridge shuttle service. The desirability of later extending high speed transit service over the river was considered in the provision of two additional tracks for that service, making four in all. Two ten-foot walk ways are provided for pedestrians.

Gradients: A decision on the grades to be used was the next step necessary. No hard and fast rule can be applied to fix the gradient of a roadway. The lighter the grade the longer the approach, with the increasing advantage to traffic offset by the increasing length and cost of approaches. The total vertical distance to be overcome enters the problem, for on a long climb lighter grades must be used than on a short one.

In this case again the precedent of the New York East River Bridges was of assistance. They have roadway grades running from 3% on the Williamsburg bridge to a maximum of 3.5% on the Queensboro bridge. Our designs were laid out so as to have no roadway grades in excess of 3½%.

On rapid transit and surface car tracks it was considered desirable to keep the grade as near 5% as possible. A maximum gradient of 5.22%, for a short distance, was necessitated at one point to get the rapid transit tracks into a subway connection.

Span and Clearance Limitations: The War Department will require the piers of the bridge to be kept back of the pier head lines so as not to encroach on the channel. The distance between pier head lines is 1690 feet on the Franklin Square-Pearl Street line. With each of the main piers 60 feet wide a main span of 1750 feet center to center of piers is called for.

The ruling of the Chief of Engineers, U. S. Army that a clearance of 135 feet would be accepted, taken in connection with the necessary thick-

ness of bridge floor construction determined the height to which the roadway must rise at the center of the river. To maintain a clearance of 135 feet under all conditions it is essential also to take into consideration the deflection of the main span due to load and temperature.

The position of anchorages and approach piers is controlled partly by the location of the streets of the two cities and partly by economic considerations. The necessity of avoiding wherever possible the cutting off of existing streets places further limitations on the approach construction. For overhead crossing of streets a minimum clearance of 14 feet was maintained.

Design Loadings: The decision as to the number of lines of traffic that should be provided for controlled the live loading to be used in designing the structure. The total live load per lineal foot of bridge with all traffic ways fully occupied is as follows:

Two lines rapid transit tracks at 2000 lbs. per lineal foot each.....	4,000 lbs.
Two lines surface cars at 1500 lbs. per lineal foot each.....	3,000 lbs.
57 feet of roadway at 70 lbs. per square foot.....	3,990 lbs.
20 feet walkway at 50 lbs. per square foot.....	1,000 lbs.
Total per lineal foot.....	11,990 lbs.

A live load of 12,000 lbs. per lineal foot was used to cover this condition of absolute maximum congested loading and all parts of the bridge designed to safely withstand the resulting stresses. Such a load would require all tracks to be continuously covered by heavy type cars loaded to their greatest seating and standing capacity, the walkways to be crowded and the roadway to be covered with loaded automobiles and trucks in close contact. All this load would have to occur simultaneously to produce a density of 12,000 lbs. per lineal foot. Actual test and observation on similar bridges has shown that this theoretical intensity of loading is never reached, and that half of the congested load may properly be taken to represent a heavily loaded condition, infrequently reached. The working live loading is therefore taken at 6000 lbs. per lineal foot for normal unit stresses. The average every day loading will be considerably less.

The roadway floor was designed to carry at any point a moving load of 30 tons.

No allowance is required for impact on the main structure in a bridge of this great weight and span. Impact, however, was considered in designing all parts of the floor system and members receiving direct stress therefrom.

Preliminary assumption of the dead load was based on information as to the weight of similar structures. A computation of stresses was made on this basis and the sections of the members determined. Estimates of the weight of the structure were then made from these sections

and the stress figures revised. This procedure was repeated twice. A complete check of weights, made after the design had been fully determined on, did not show enough change to require any further revision in stresses.

Wind loading was considered to cause a pressure of 50 lbs. per square foot of exposed area.

Temperature stresses were computed for a variation of 55 degrees above and below normal temperature.

Materials: All main truss members, towers, floor beams and some bracing were designed for high strength alloy steel. A medium carbon steel was used for remaining steel construction except the cable and hangers of the suspension bridge design. For these high carbon steel wire possessing even greater strength than that used in the New York suspension bridges is available. In No. 6 size (.192 inch diameter) this wire has an ultimate strength of 215,000 lbs. per square inch and an elastic limit of over 144,000 lbs. per square inch.

This bridge will from its size and location inevitably be of a monumental character. On account of the large sum that will be invested in it, the construction should be such as to maintain the appearance and durability of the structure unaffected by the elements to such an extent as is practicable. For its inherent fitness to these two considerations we have designed all exposed masonry construction in granite, with backing or cores of concrete. Reinforced concrete is utilized for the roadway slab and for certain structural elements in the approach subways and anchorage.

SELECTION OF SPAN TYPE

After decision on capacity of the structure the next important step was to choose the types of span that deserved study for the main bridge.

The simple truss is, of course, the most frequently used in bridge construction. The maximum span of this type yet built does not exceed 720 feet in length and the practicable limit is not much greater than that. Simple spans could only be used here if a low level bridge, with several piers in the river channel, were permissible. The low level type of bridge was studied and reported against in 1915 by the Bureau of Surveys of Philadelphia, before the attitude of the War Department as to keeping piers out of the channel was known. It was stated then that the piers would be a menace to shipping, that the opening of the necessary draw span would at all times be awkward for bridge traffic and unendurable for the great interurban crowds at rush hours. In addition, as more than half of the traffic is bound for points inland from the water's edge it is better served by the free traffic way afforded by the bridge approaches than by being forced to travel the entire distance through congested city streets.

The types available for long span construction are the suspension, cantilever and arch. The last type is dependent upon absolute stability of abutments for its security and is hardly suitable for a location where

rock is not found at a high elevation at the abutment sites. No arch has yet been built with a span in excess of 1000 feet.

The decision therefore rested between suspension and cantilever types, each of which has been used in bridge spans of approximately this magnitude.

Points of Superiority—Cantilever: The cantilever bridge is without question more rigid than the suspension, and it is this feature principally that has recommended it over the other type for long span railroad bridges. Due to this rigidity it has less deflection under live load and as temperature has no appreciable effect on the elevation of its roadway, there is less variation between the maximum and minimum clearance afforded under the span. Taking advantage of this, the roadway need not be carried so high above the channel, and the approaches consequently can be made shorter. The anchor piers need only be of sufficient size and stability to resist the direct upward reaction of the anchor arm, where in the suspension type a far greater mass is required to resist the almost horizontal cable pull. As the anchor piers are smaller, the Philadelphia one could be placed at the bulk head line and the less expensive approach construction be used instead of a longer anchor arm, over Delaware Avenue.

Points of Superiority—Suspension: The suspension bridge requires far less metal than the cantilever—a total of 33,000 tons as against 47,000 tons. This advantage is partly offset by the greater cost of the anchorages and the more costly material in the suspension bridge cables—but taking all into consideration detailed cost estimates show a difference of \$1,986,000 in favor of the suspension bridge. Even were the cost the same, the suspension bridge would be more suitable to this location because of its greater gracefulness and beauty of line. The practical difference in rigidity between cantilever and suspension bridges under highway loads is unimportant when the suspension bridge is adequately stiffened. No one could complain of the Manhattan bridge in this respect. Another important advantage of the suspension type is that while the contract for the entire superstructure of the cantilever would have to be let to one contractor at one time (requiring a least \$10,000,000 to be available at that time) the superstructure of the suspension bridge could be advantageously split into several partial contracts. These contracts could be let in sequence as funds are available.

Experience has shown that the suspension bridge involves less risk in construction. It can also be manufactured and erected more quickly, saving possibly an entire season in building the bridge.

There is a possibility with a suspension bridge that would not exist with the cantilever design of providing increased capacity after completion if ever found necessary. The suspension type has less exposed surface of metal to be kept painted, and is therefore more economical in maintenance.

Selection of Suspension Design: Before making a decision between these two forms of construction we prepared complete general designs of each sufficient to make detailed estimates of cost. A very careful analysis

was made of the unit cost used, checking them against actual costs in the past and under present day conditions.

Architectural studies were made as to the treatment of both designs and especial attention devoted to securing the most pleasing proportions.

After comparison of the respective advantages of the two designs we concluded that the suspension type is decidedly preferable for this bridge.

MAIN SPAN DESIGN

Suspension bridges, following their prototype, the swung rope, are ideally adapted to sustaining their own weight and that of uniformly distributed moving loads. As actual moving loads are however not uniform, but of a more concentrated and discontinuous character, it has been found necessary to stiffen the cables against excessive local deformations. The simplest method of stiffening, used in all great bridges of this type, is by attaching to the cables trusses of sufficient rigidity. These trusses directly sustain the roadways. They also can be braced so as to afford sufficient resistance to wind forces. The cables and their stiffening trusses act as a single composite structure. The great advance which has been made in recent years in the theory of proportioning the parts of suspension bridges consists in a more correct understanding and analysis of the part performed by each of the essential elements in the structure.

General Layout of Spans: The main span length is fixed by the Federal requirements of clear channel. On the Franklin Square-Pearl Street line this length is 1750 feet between towers. During the last fifty years since the Brooklyn bridge was designed with a span of 1596 feet, only one suspension bridge, the Williamsburg, has exceeded it in length and that only by four feet. The Delaware River bridge therefore marks an important advance in length of span, surpassing by 150 feet the longest suspension bridge in the world.

Local conditions require that the cables be carried to an anchorage a considerable distance back of the towers and it is therefore economical to suspend the side spans from them. The cables and towers necessary for the main span sustain the fixed load of the side spans with but a very small increase in size and at little additional cost. It is desirable that the side spans be something less than half the main span in length. This condition and the necessity of not encroaching on Delaware Avenue in Philadelphia governs the location of the anchorage, the face of which coincides with the west building line of that street. Symmetry determines the location of the Camden anchorage.

Versed Sine: The dimension which has the most important effect on the economy of design of a suspension bridge is that of the sag, or

versed sine, given the cables. This dimension is the vertical distance between the highest point of the cable curve at the towers and its lowest point at mid span. On the choice of this depend the size of the cable, the height of the towers, the weight of the anchorages and the pressure on their foundations. The stresses in the stiffening trusses are also in great measure influenced by it. For this design 200 feet was chosen as the versed sine best suited to the requirements of the bridge and its economy.

Arrangement of Roadways: The arrangement of the traffic lanes which it had been previously decided the bridge was to carry was given much study. To place all on one level would call for a width of deck of at least 146 feet. If distributed on two levels, the approaches would have to be longer to get the vehicles or cars on and off the upper deck. The simple expedient of placing the walkways on the upper lateral bracing and grouping the vehicle and car roadways on the lower levels, reduced the required width to a desirable figure and permitted a minimum length of approach. The roadway was placed inside the carlines so that it might be in one unobstructed width and the arrangement yet be symmetrical.

First consideration was given to the suspension of the roadway from four main cables, as used in all the New York bridges. With the desired traffic way arrangement, the four cables involved a width between outside tower legs of 118 feet and main pier caissons 170 feet long. The two cable design, finally adopted, permits the two tower columns to be placed 89 feet apart and saves 25% in the cost of main piers alone. Aside from a considerable saving in total stiffening truss weight and greater economy in all details, it gives a much more definite distribution of load to the cables.

Cables: Roebling, in planning the Brooklyn bridge, decided upon a $15\frac{3}{4}$ inch cable to support its then unprecedented span. Each of the two succeeding East River bridges, while still adhering to four cables, marked a step in advance as to their size. The Williamsburg cables are $18\frac{5}{8}$ inches in diameter and those of the Manhattan $20\frac{1}{2}$ inches. The choice of a two cable design for the Delaware River bridge span, requires a notable increase in cable diameter to 30 inches. Despite this fifty percent increase the manufacture and erection of the cables will involve no new or untried procedure. Each wire of the 16,500 composing each cable will be of approximately the same diameter as previously used and can be put in place by the same methods and with apparatus similar to that used on the smaller cables heretofore. The wires would be laid in place individually and parallel to make up 61 strands, which would be subsequently bound together and wrapped with serving wire, to make up the complete cable. The single wires would be 0.192 inch in diameter, of very fine quality high carbon steel, galvanized.

Every $20\frac{1}{2}$ feet measured horizontally a circumferential cast steel saddle will be fastened to the cable, over which four galvanized wire ropes, $2\frac{5}{8}$ inch diameter each, will be hung to carry the suspended structure.

The cables rest on cast steel saddles on the towers and at the anchorages. Back of the anchorage saddles they are fastened to anchor chains embedded in the mass of the anchorage masonry.

The Stiffening Trusses: The function of the stiffening trusses is to distribute, more or less uniformly, the discontinuous and concentrated live loads that come onto the bridge. The dead load of the trusses themselves and the floor system is carried by the main cables. This is secured by erecting the trusses and floor system freely suspended from the cables with joints unriveted. The entire weight is thus thrown onto the cables which assume their natural loaded curve. The joints in the trusses are then riveted together, after which the entire bridge acts as a unit.

The deflection of the bridge in service is caused by the elongation of the cables under added load and change of temperature. It is resisted by the weight of the entire structure and the rigidity of the trusses. It is the part of good design to select trusses of rigidity sufficient for the character of travel without employing too much material. Great depth of truss is now known to be not necessary or desirable and 28 feet was adapted for this design.

The usual traffic over the bridge will produce loads more or less uniformly distributed along the spans and the stresses caused in the stiffening trusses will be but a small fraction of the greatest stresses which might occur under abnormal and improbable conditions of loading and temperature. The conditions are thus particularly favorable to the use of high-strength steel. With it the trusses have sufficient rigidity in the usual ranges of working stresses while possessing a reserve strength that provides for the wide range and high values that might infrequently occur.

It is most desirable to transmit the loads to the cables as uniformly as possible and short panel lengths have ever been characteristic of suspension bridges. A panel length of 20.5 feet was used for the main span and 20.75 feet for the side spans. The Warren, or simple triangular system, is admirably adapted to the reversals of stress that the truss is to be subjected to.

The suspenders take the load to the cables at each panel point. The chords of the trusses are made up of two channel sections, four feet deep, well laced together, and the diagonals and verticals have an I section with solid web.

The reactions of the stiffening trusses at the towers are taken by stiff hangers, connected by bushed pins to the towers. This enables the trusses and floor to expand and contract freely at these points when their length changes with the temperature.

The stiffening trusses were computed according to the Deflection Theory, first used on the Manhattan Bridge. It is based on the behavior of the bridge as to composite structure and takes into account the part which the total weight of the structure plays in resisting the cable deformations. The stresses are computed for the specified moving load of 12,000 lbs. per lineal foot, and a temperature range of 110 degrees, to cover all conditions of loading and temperature.

The Towers: Next to the cables the most important members of a suspension bridge are the towers. In the early suspension bridges, with small spans and light loads, masonry towers were mostly used. The Brooklyn Bridge, with its long span, has stone towers, but in all succeeding suspension bridges of that magnitude the towers have been built of steel. The reason for the departure from masonry is purely a matter of practical engineering. There is no doubt that well proportioned masonry towers produce a fine aesthetic effect but structurally they cannot satisfy the engineering requirements of a large bridge.

Under various conditions of loading the resting points of the cables on the tops of the towers are subject to considerable horizontal displacements. Formerly, it was common practice to place the cable saddles on roller beds, which were relied upon to permit this motion. Experience on large bridges has shown that the rollers and saddles do not move until frictional resistance of considerable magnitude has been overcome. This means that the towers must bend to permit this horizontal displacement. The large dimensions which masonry towers require to sustain the enormous reaction of a long span bridge make them unfit for bending. The necessary lateral width causes difficulty in securing sufficient clearances at the point where the roadway passes through the tower.

It is much better to avoid the uncertainty of response of the rollers by fastening the cables securely to the tops of steel towers and designing the latter so that they can safely deflect in the plane of the cables as much as may be required to permit a balancing of the horizontal forces. The proper proportioning to bring this about, when the towers are fixed at their base, results in slender and graceful lines. The strength to withstand the bending stresses in addition to the direct stresses is provided by the addition of the proper amount of material.

The large versed sine fixed for the cables results in the towers attaining a height of about 380 feet above water level. The great length of the tower legs gives favorable bending stresses under the required horizontal displacements. The legs have a width parallel to the cables of 12 feet at the top, widening to 40 feet at the base. Transversely the width is 7 feet, above the floor level. The tower legs are substantially braced to form a unit. The towers have been designed with a minimum of superimposed ornament, in keeping with the general lines of the structure.

Anchorages: The function of the anchorages is to hold the ends of the cable securely fixed against its maximum pull. Where, as in this case, it is not practicable to embed the ends of the anchor chain in solid rock, a sufficient mass of masonry must be provided so that the anchorage can resist the pull by its weight, and the foundation so constructed as to prevent slipping. At the point where the cable enters the anchorage it finds support, and changes direction, on a saddle resting on a steel pedestal. The latter, in turn, carries the load past the bridge roadway down into the masonry. After passing the anchorage saddle the wire strands of

the cable are connected to a chain of 122 eyebars, which are in turn fastened to steel girders embedded in the base of the anchorage.

The anchorage masonry is designed as a monolith, to receive the cable reactions and distribute them over the foundation as uniformly as possible. Each anchorage will require 90,700 cu. yds. of masonry and will rest on gravel strata and on inclined caissons extending down to rock or other satisfactory material. The horizontal pull of the cables combined with the weight of the anchorage produces a resultant inclined to the vertical about one foot in six feet. To avoid any possible doubt as to the resistance to sliding of the anchorage it is intended to sink 20 small caissons to hard foundation with the same inclination as the resultant of the forces.

To give access to and from the river front districts for passengers, elevator shafts are provided in each anchorage. These will have an ultimate capacity of four passenger elevators, connecting the footwalks and the surface car stations that are planned at each anchorage with the ground level.

The anchorages are the principle feature architecturally of the design. Their treatment is based on the principle of expressing the constructive features and achieving a decorative effect by an outline of the greatest simplicity. This is the only way to harmonize the steel construction with the stone work. A comparison of existing bridges has shown that the most beautiful ones are not those where architectural decoration has been lavished, but those where the masonry and the steel work are designed in the same character.

Floor System: The short panels of the stiffening trusses result in an economical and simple floor system. All roadway and track stringers are rolled beams. Clearance limitations make it desirable that the floor beams be kept at a minimum depth; this is favored by the short panel length. The tracks are to be carried on steel ties and the roadway paving on reinforced concrete slabs with adequate provision for expansion and contraction. Except for the proposed wood block pavement there will be no inflammable material used in the bridge. As the wood block would not burn without draft from below, the structure will be fireproof to an extent never attained before in a long span highway bridge.

APPROACHES

Selection of Type of Approach Structure: For this structure suggestions have been made from time to time that constructions departing from the usual single approach type be used. Spiral roadways and double approaches, running either at right angles to the main bridge or diagonally in Y-shape or in long curves have been suggested.

The spiral approach would be an economically unsound attempt to save initial outlay. Its result would be confusion and congestion, to correct which great sums would have to be spent in the end to widen streets or provide supplemental approaches of the usual type. It would re-

quire all that greater portion of the traffic which originates inland on either side of the river to travel double distance in reaching the main span. This traffic would have to pass through the city streets at grade and then, on reaching the riverfront, travel up the spiral the same or a greater distance.

All the split roadway schemes have the disadvantage of excessive cost. The reasons for this are inherent in the double approach idea. Even if each of the two approaches could be built with but one-half the capacity of the straightaway approach, the total construction would cost more because of the items such as side retaining walls, parapets and railings, new streets alongside, plazas and architectural treatment, which would be doubled. But as a roadway 30 feet wide does not have half the capacity of one 60 feet wide and as street car tracks and rapid transit lines would have to extend to both terminals, the cost of the split approach structure only would be at least 75% in excess of that for the type of approach we recommended.

Any of the two-way approaches would necessitate the creation of a very expensive elevated plaza at the bridge anchorage to properly handle the intersection of the traffic streams from the two directions.

All our studies, have, therefore, been based on the use of single approaches, either straightaway, or curved laterally, as conditions required. A number of different types of supporting structures were planned and estimated before the selection of the design shown on Plate XIV and XVI. These included series of reinforced concrete arches, cellular masonry walls, steel girder and tower construction and the adopted Warren truss spans on masonry piers. The last design was found to give the greatest economy compatible with good appearance.

Its use permits of unobstructed open spaces under the approaches which can be utilized for construction of warehouses or markets as separate structures if deemed expedient. Experience in New York has shown that such space can be made a substantial source of revenue. As any structures beneath the bridge must be thoroughly fire-proof and should be of a design harmonious with the bridge itself, leases should require approval by the Joint Commission as to type and appearance of any buildings to be erected.

General Characteristics of Approach Structures: The Warren trusses were adopted because they harmonize with the main span construction. The spans range in length from 132 to 192 feet, most of them being 160 feet. The trusses are placed 95 feet center to center. One track is carried on the inside and one on the outside of each truss. The trusses and footwalks above them follow the gradient of the transit tracks, while the roadway is on a lighter grade. A reinforced concrete floor slab is used as in the main bridge.

The masonry pedestals will rest on concrete piles or on compact gravel and be built of concrete, faced with granite to be in keeping with the main span construction.

Where the approaches are near ground level, the roadway and tracks are carried on earth fill between concrete retaining walls of gravity sec-

tion. These walls would be granite faced and topped with a granite balustrade.

It has been contemplated that stairways might be provided from the sidewalks on the approaches to Third Street in Philadelphia and at a similar point along the Camden approach, in order to make the bridge accessible for pedestrians in those vicinities.

The roadway on both the Philadelphia and the Camden approach is widened from the 57-foot width of the main spans to 63 feet. This represents a width a foot greater than the roadway of Market Street, Philadelphia, free from car tracks, and will permit of the arrangement of the lines of travel according to their different speeds with ease and safety before the river section of the bridge is reached.

Plaza Development: It is obvious that a bridge will carry no more traffic than can get on its approaches. Great width of roadway on the bridge will be wasted expense unless adequate provision is made at the terminals for receiving and distributing the traffic from and to the network of the city streets. Not only must there be roadways leading from the bridge end in several directions but these must radiate from an ample paved space in which distribution can take place. The combined widths of the distribution roadways must be considerably greater than that of the bridge roadway to allow for the slowing up in speed of vehicles as they leave the unimpeded roadway on the bridge to commence their progress through the streets.

At the Philadelphia end of the bridge we have planned a plaza occupying the entire area bounded by Fifth, Sixth, Race and Vine Streets. Through this plaza there are four roadways with a combined width four times that of the bridge roadway. These short avenues radiate from the central open space immediately at the bridge end. The dimensions of this area are 184 feet by 228 feet, in which a suitable traffic circle could be established. This would permit distribution between approach avenues and bridge roadway on the gyratory principle without intersection and conflict of the various lines of travel.

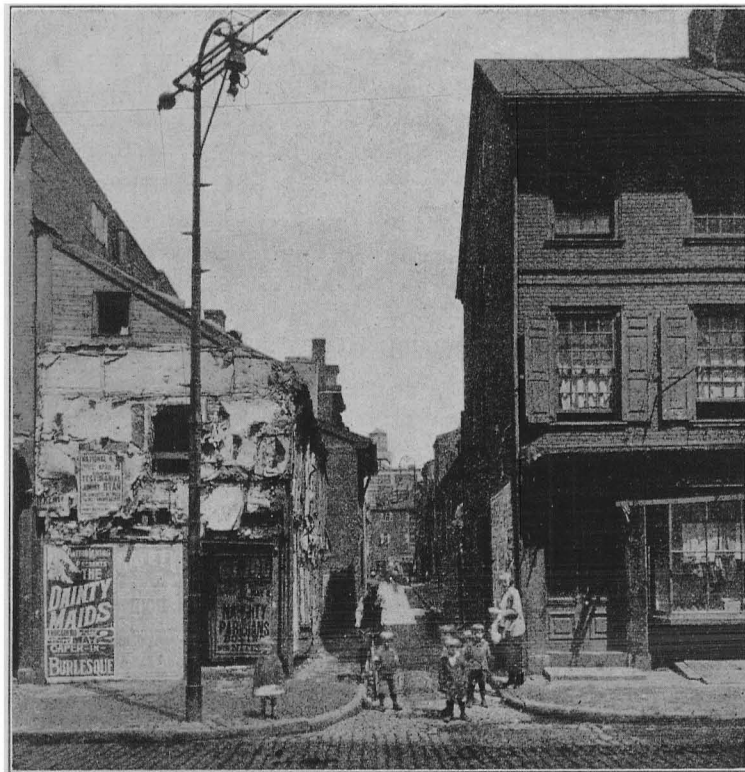
This plaza development does not absorb any of the existing Squares of the city, but on the contrary materially adds to Franklin Square. The entrance to the underground station from the level of 6th Street has been so treated as to give an effective setting to the approach to the bridge, without any unnecessary features. In a general way, it has been attempted to keep the approaches both in Philadelphia and Camden as free as possible from superstructures, instead of shutting them off with triumphal arches or lofty pylons. These motives seem out of place on a bridge, which is primarily a thoroughfare to be kept as open as possible.

It would be highly desirable that the two plots just east of the Philadelphia plaza on the north and south sides of the bridge, be controlled by the Joint Commission. On these could be placed two buildings, public or semi-public in nature, with facades conforming to a uniform architectural treatment. This would make a most suitable portal to the bridge.

At the Camden end, the approach structure comes to grade 50 feet east of Fifth Street but the roadway is continued to a plaza bounded by Sixth, Seventh, Penn and Linden Streets. Ten percent. of the traffic

would come from or wish to go to the north and northeast and would have an opportunity to enter or leave the traffic stream at this plaza circle. The remaining 90% of the traffic to New Jersey, according to its present day proportions, would not seek to separate at this point, but would swing around the traffic circle in the plaza and head towards Camden County Court House. Our plan recognizes that the real traffic center must ultimately be created nearby and east of the Court House for proper distribution to the New Jersey Highway system.

Both plazas are planned for formal park development, without elaborate and costly ornamentation. They will provide proper and needed terminals for the great bridge and would be notable additions to the open spaces of the two cities.



A district which would be changed to make way for the Bridge Approach to Franklin Square.

Arrangement of Transit Lines: As rapid transit service over the bridge, from the Philadelphia lines to Camden, must wait upon the completion of the authorized subways, we have considered that a bridge shuttle service should be provided at the time the bridge is opened. Such a shuttle line can be equipped and operated at a sufficiently reasonable cost to insure a good return on the investment, provided that a moderate rate of fare be charged, similar to that on the shuttle line operating over the Manhattan Bridge in New York City. This would offer a source of revenue, either through lease or direct operation.

At the Philadelphia end of the bridge the intersection of the highway traffic streams by the bridge car tracks is avoided by running the latter underground. The surface, or bridge shuttle service, car tracks operate through a 5-loop terminal station beneath the plaza. The rapid transit tracks are arranged for subway connection to the Philadelphia high speed system.

The surface car terminal is so designed that it can be entered at grade from Sixth Street to a mezzanine floor. This mezzanine space has ample area for handling the incoming and outgoing passengers and to provide for comfort stations, first aid rooms, storage rooms and the like. Separate stairways lead to and from each of the five loading loops, each of which will accommodate two cars. Stations of this type avoid all crossing at grade of the car tracks and permit the separation of incoming from outgoing passengers. They have been found to be very successful in handling large numbers of people without confusion during rush hours. Experience has shown that 12,500 passengers per hour could be regularly handled in and out of a 5-loop station such as provided here.

It would be possible to depress the present surface car tracks on Sixth Street from a point north of Vine Street to a point south of Race Street into a 2-track subway. This would leave Sixth Street free from tracks in front of the bridge plaza and do much towards preventing congestion. It would also allow direct connection between Philadelphia surface car tracks and the bridge lines (provided proper provision were made as to gauge of tracks) if such an arrangement were desired.

The rapid transit tracks on the bridge are depressed to the north and south of the underground station and loop around it to Sixth Street. Here there can be either a direct extension of tracks to connect with the Philadelphia system, or a subway station where passengers could interchange between bridge line and city line as conveniently as the transfer is made between express and local subway trains in New York City.

Our transit arrangements at this terminal have been made as flexible as possible to provide for all the various conditions that might prevail when the bridge is put into use.

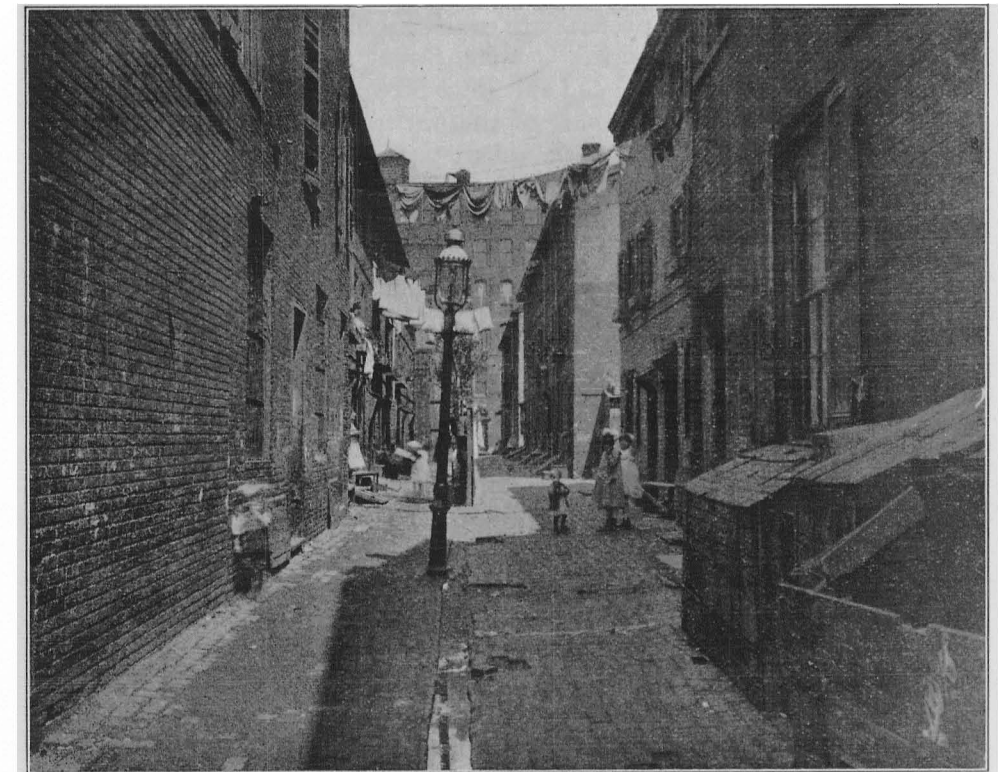
In Camden, the surface car tracks would leave the bridge approach at Fourth Street and loop at grade through Camden streets (as shown on Plate XVII) to Mickle Street and return north through Fifth Street. This would permit passengers to reach the lines of the Public Service Railway Company and also the Broadway Station of the Pennsylvania Railroad.

Such a surface loop could probably not handle the traffic for many years after the bridge is opened. We therefore suggest as a later development the construction of elevated tracks either to a stub end terminal near the present Federal Street ferry plaza or in a loop around a portion of Camden. The latter scheme, although more expensive, would permit of connection with possible future rapid transit extensions into outlying New Jersey points and would be suited to use in connection with a Camden Union Station for the railroads. The spur to Federal Street plaza would involve no rearrangement of present railway and electric

transportation lines and terminals. The construction of the Camden approach would be such as to permit either arrangement, as might develop to be best.

CHANGES IN STREETS

The problem of street capacity in Philadelphia has been a matter of serious concern to those charged with the responsibility for its development for years past. Conditions would be today beyond sufferance were



The Bridge Approach to Franklin Square would take property such as this for much of its length.

it not for the presence of Broad Street running north and south and Market Street running east and west. The recommendation of those who have given serious study to the situation in the past has been the creation of a traffic circuit around the central business district by the widening of two east and west and two north and south thoroughfares. These would relieve traffic congestion by providing increased street area, and furnish an opportunity for the enlargement and improvement of the business districts in the center of the city. Actual putting into effect of these measures has lagged from too keen appreciation of their cost and too little understanding of the ultimate effect of leaving them undone. The rapid

growth of motor driven traffic is bringing citizens to realization that the work cannot be much longer delayed.

The traffic circuit recommended by the Committee on Comprehensive Plans in 1914 was to be obtained by the widening of 16th Street, Race, Eighth and Locust Streets. Development of business since that time has indicated that a somewhat larger area should be included within the circuit. The Bureau of Surveys of the City of Philadelphia favors widening Pine Street on the south, Vine Street on the north, Twentieth Street on the west and Seventh or Eighth Street on the east. Figure 2 shows how well the Franklin Square Bridge plaza fits into such a scheme. By widening Race and Vine Streets between Sixth and Eighth Streets a very desirable circulation would be provided. Vine Street would receive the west bound travel from the bridge end and Race Street would deliver east bound travel to it. An important part of the north and south traffic would be directed into the widened Eighth Street, passing to and from the bridge through Race and Vine Streets. The remainder of the traffic would be accommodated north and south on Fifth and Sixth Streets, or to and from the river by the two new streets parallel to the bridge line.

These streets have been planned on either side of the entire length of the Philadelphia approach, to give the river front traffic access to and from the bridge. They are each 50 feet in width, with a 36-foot roadway, and we have included in our estimate the cost of extensive grade revisions at Front Street in order that they should not have a gradient heavier than 4.7%. Vine, Race, Arch and Market Streets now have 8 to 10% grades between Front and Water Streets, which are a severe obstacle to traffic moving inland from the river. The new streets would be a very great improvement.

As an alternative, if the Traffic Circuit is not authorized before the completion of the bridge, we have studied the widening of Vine Street from Sixth to Broad Street, of Sixth from Market north to Spring Garden Street and of Ridge Avenue from Vine Street to Broad Street. (Fig. 1 and Plate I.) A minimum width of roadway of 70 feet 9 inches is recommended for Sixth Street and of 78 feet for Vine Street in this case. For comparison the width of Broad Street is 69 feet, curb to curb. With elimination of parking in Race Street, this street and the widened Vine Street would have a maximum capacity of not less than 5500 vehicles per hour. The two streets now handle an average combined maximum traffic of 670 vehicles per hour, and would receive over 2500 additional ones with the bridge operating at capacity.

On the Camden side of the river, we have shown a new avenue, or mall, parallel to and between Sixth and Seventh Streets, running from the bridge plaza to a traffic distribution and collecting center east of the Court House. This would be ample to carry all the traffic the bridge can handle, or that could be delivered and absorbed by Broadway, Haddon Avenue, Federal Street and the others radiating from that central point.

Any plans for the development of Camden's streets at the bridge end which would throw the additional bridge traffic into the already congested



Old warehouse structures along Delaware Ave. on the site of the Philadelphia anchorage at the recommended location.

center would be an error. The solution of the problem of the congestion around the Court House is to open up the two main highways (Haddon Ave. and Broadway) at their ends and, between their intersection and the plaza at the bridge end, provide a wide distribution area which will give outlet to a portion of the bridge traffic, to the east and to the west, without requiring it to pass through the Court House center. The open space proposed east of the Court House and the mall between it and the bridge plaza would answer these requirements. They would provide in addition a worthy setting for the Court House itself.

ESTIMATE OF COST

Estimates of cost at the three most favorable locations have been prepared. The quantities of various materials and work to be performed were calculated from plans and detailed studies. The unit prices applied to these quantities were obtained from cost records on previous work revised for present conditions and by consultation with various contractors and manufacturers as to the now prevailing prices.

The amount shown in these estimates as the cost of property to be acquired is arrived at by an addition of 25% to the latest assessed valuations. This is the probable average increase over assessed values, assuming that a fair portion of the property can be purchased at assessed valuation, or at assessment plus 10%, as was done in the case of many of the properties acquired for the Parkway improvement.

These estimates are as follows:

ESTIMATE OF COST OF BRIDGE—FRANKLIN SQUARE-PEARL ST. LOCATION

Main Bridge	\$13,355,000
Philadelphia Approach (Including Underground Station, Plaza, Paving, Grade Revision, Sewers, etc.)	3,579,000
Camden Approach, Plaza, Paving, etc.	2,639,000
Electrical Equipment for Lighting, Maintenance Plant, etc.	250,000
	\$19,823,000
Contingencies—5%	991,000
	\$20,814,000
Engineering—6%	1,249,000
Administration—2%	416,000
COST OF CONSTRUCTION.....	\$22,479,000
Real Estate (Philadelphia)	\$4,485,000
(Camden)	1,603,000
	6,088,000
Contingencies and Cost of Acquiring Real Estate—5%	304,000
TOTAL COST OF BRIDGE.....	\$28,871,000

RECOMMENDED STREET WIDENING

Immediate increase of street facilities needed upon completion of Bridge (If Traffic Circuit is not constructed):

Widening of 6th St., Phila. (Market St. to Spring Garden St.)	\$1,865,250
New Street from Camden Plaza to Federal St.	881,625
Property Damage	\$2,746,875
In Philadelphia, the widening of 6th St. to be followed by widening of Vine St. and Ridge Ave.:	
Widening of Vine St. (6th St. to Ridge Ave.)	\$552,875
Widening of Vine St. (Ridge Ave. to Broad St.)	2,692,000
Widening of Ridge Ave. (Vine St. to Broad St.)	1,162,750
Property Damage	\$4,407,625

DIVISION OF COST OF BRIDGE — FRANKLIN SQUARE-PEARL ST. LOCATION

	<i>Pennsylvania</i>	<i>New Jersey</i>	<i>Philadelphia</i>	<i>Total</i>
Main Bridge	\$3,338,750	\$6,677,500	\$3,338,750	\$13,355,000
Philadelphia Approach (Including Underground Station, Plaza, Paving, Grade Revisions, Sewers, etc.)	1,789,500		1,789,500	3,579,000
Camden Approach, Plaza, Paving, etc.		2,639,000		2,639,000
Electrical Equipment for Lighting, Maintenance Plant, etc.	62,500	125,000	62,500	250,000
Contingencies—5%	\$5,190,750	\$9,441,500	\$5,190,750	\$19,823,000
	259,500	472,000	259,500	991,000
Engineering—6%	\$5,450,250	\$9,913,500	\$5,450,250	\$20,814,000
Administration—2%	312,250	624,500	312,250	1,249,000
	104,000	208,000	104,000	416,000
COST OF CONSTRUCTION	\$5,866,500	\$10,746,000	\$5,866,500	\$22,479,000
Real Estate	2,242,500	1,603,000	2,242,500	6,088,000
Contingencies and Cost of Acquiring Real Estate—5%	112,000	80,000	112,000	304,000
TOTAL COST OF BRIDGE	\$8,221,000	\$12,429,000	\$8,221,000	\$28,871,000

COMPARISON OF COSTS OF BRIDGE AT THREE LOCATIONS

	<i>Pennsylvania</i>	<i>New Jersey</i>	<i>Philadelphia</i>	<i>Total</i>
FRANKLIN SQUARE-PEARL ST. LOCATION				
Cost of Construction	\$5,866,500	\$10,746,000	\$5,866,500	\$22,479,000
Real Estate	2,354,500	1,683,000	2,354,500	6,392,000
TOTALS	\$8,221,000	\$12,429,000	\$8,221,000	\$28,871,000
SPRING GARDEN-STATE ST. LOCATION				
Cost of Construction	\$5,898,000	\$10,717,000	\$5,898,000	\$22,513,000
Real Estate and Damage to Railroad Terminals	2,647,250	1,672,500	2,647,250	6,967,000
TOTALS	\$8,545,250	\$12,389,500	\$8,545,250	\$29,480,000
WASHINGTON SQUARE-FEDERAL ST. LOCATION				
Cost of Construction	\$6,025,000	\$11,015,000	\$6,025,000	\$23,065,000
Real Estate and Damage to Railroad Terminals	3,731,000	8,123,000	3,731,000	15,585,000
TOTALS	\$9,756,000	\$19,138,000	\$9,756,000	\$38,650,000

We desire to express our appreciation of information and assistance received from the Departments of City Transit, Wharves, Docks and Ferries, the Bureau of Surveys and Bureau of Highways of the City of Philadelphia and from the officials of the City of Camden. The co-operation of the Pennsylvania Railroad Company, the Philadelphia and Reading Railway Company, the Philadelphia Rapid Transit Company, and the Public Service Railway Company of New Jersey has been of material aid in furnishing data as to past and present traffic on the ferries and transportation lines. Our airplane views are by courtesy of the Aero Service Corporation. We also wish to make acknowledgment of valuable assistance received from individuals and organizations engaged in construction work, in passing on unit costs used in our estimates. By these and others who have placed information at our disposal we have been assisted and speeded in our studies of this complicated problem.

This concludes our report. In gathering the necessary information and preparing figures hereinbefore submitted, we have endeavored to compare and co-ordinate in a fair and impartial way all interests concerned, and to arrive at a solution which will serve the majority of the public. It is not possible to satisfy the desires of all interests by one bridge—there are bound to be individuals or organizations who would prefer another location as favoring their immediate interests but we believe that our solution of the problem will meet the needs of the greatest number of those who are now inconvenienced by the absence of a permanent crossing, and at the same time will provide a structure at a reasonable cost, capable of taking care of public needs for some time to come.

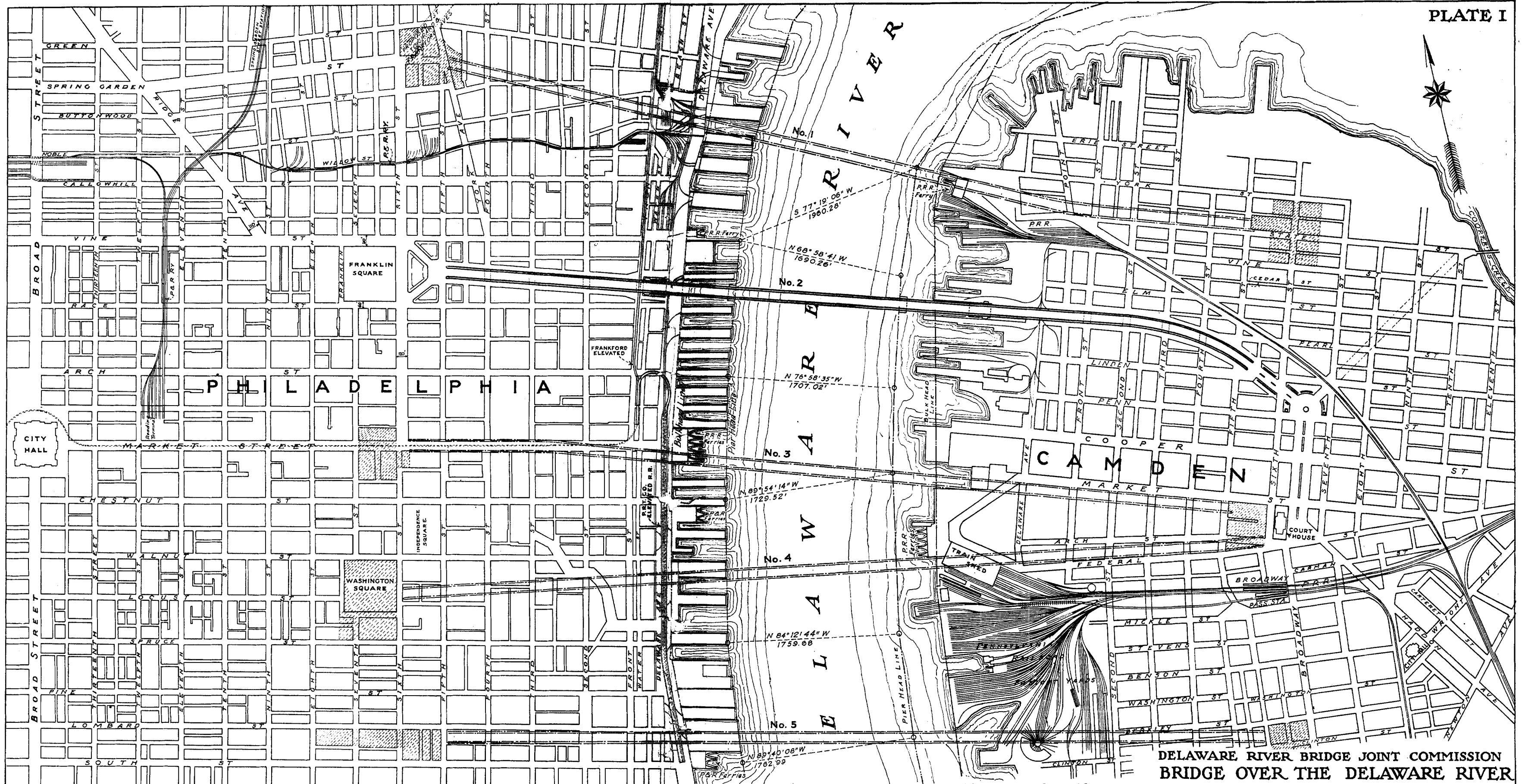
While making traffic studies it became more and more apparent to us that a permanent crossing of the River, such as the Bridge will provide, is a public necessity at this time.

The design as here recommended can be built by July 4, 1926, the Sesquicentennial of the Declaration of Independence. Its construction will go hand in hand with the great Universal Exposition planned for that year and when completed it will mark an epoch in the development and growth of not only Philadelphia and Camden but of the States of Pennsylvania and New Jersey.

Respectfully submitted,

RALPH MODJESKI, *Chairman*
GEORGE S. WEBSTER,
LAURENCE A. BALL.

June 9, 1921.



GENERAL NOTES

- No. 1 - (Indicates Spring Garden and State Streets Location)
No. 2 - (Indicates Recommended Location (Race and Pearl Streets)
Complete with Plazas - also New and Widened Streets
Areas Marked thus Indicates Plazas for Respective Locations
- No. 3 - (Indicates Market Street Location)
No. 4 - (Indicates Washington Square and Federal Street Location)
No. 5 - (Indicates Lombard and Clinton Streets Location)

BOARD OF ENGINEERS

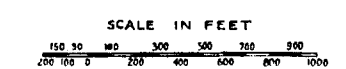
Russ Morgan Chairman
E. J. Webster
James C. Hall

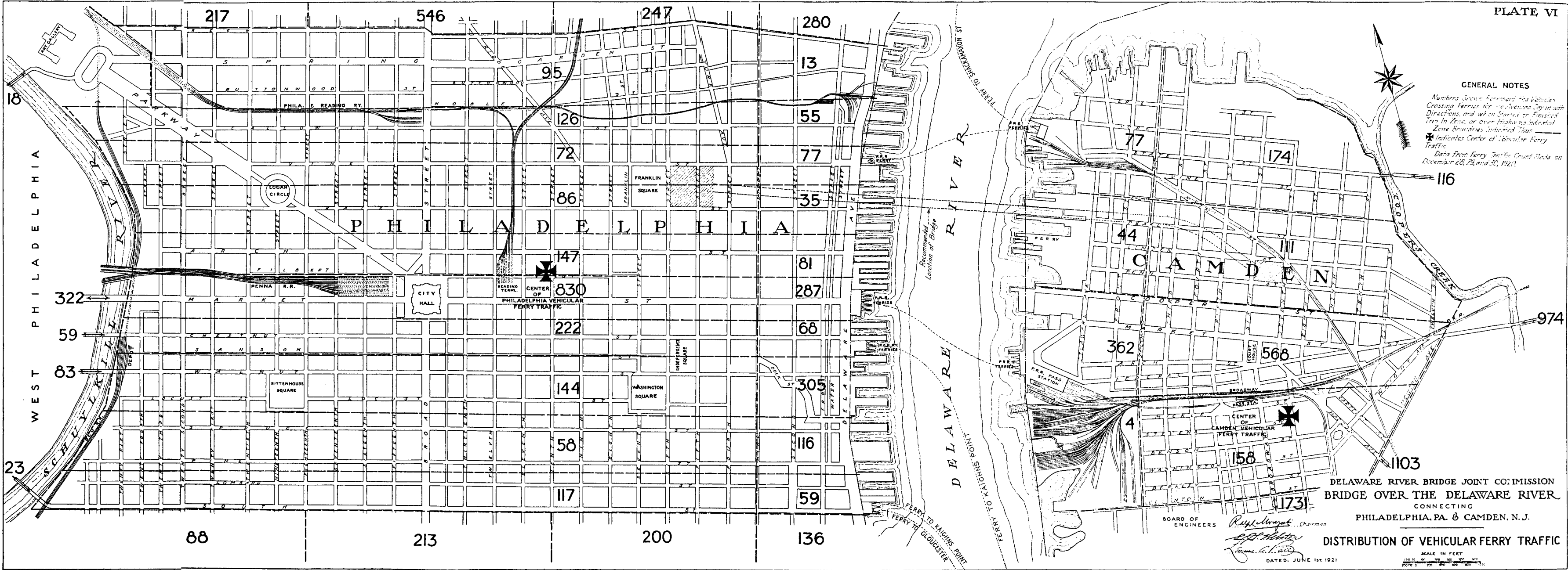
DELAWARE RIVER BRIDGE JOINT COMMISSION
BRIDGE OVER THE DELAWARE RIVER
CONNECTING

PHILADELPHIA, PA. & CAMDEN, N. J.

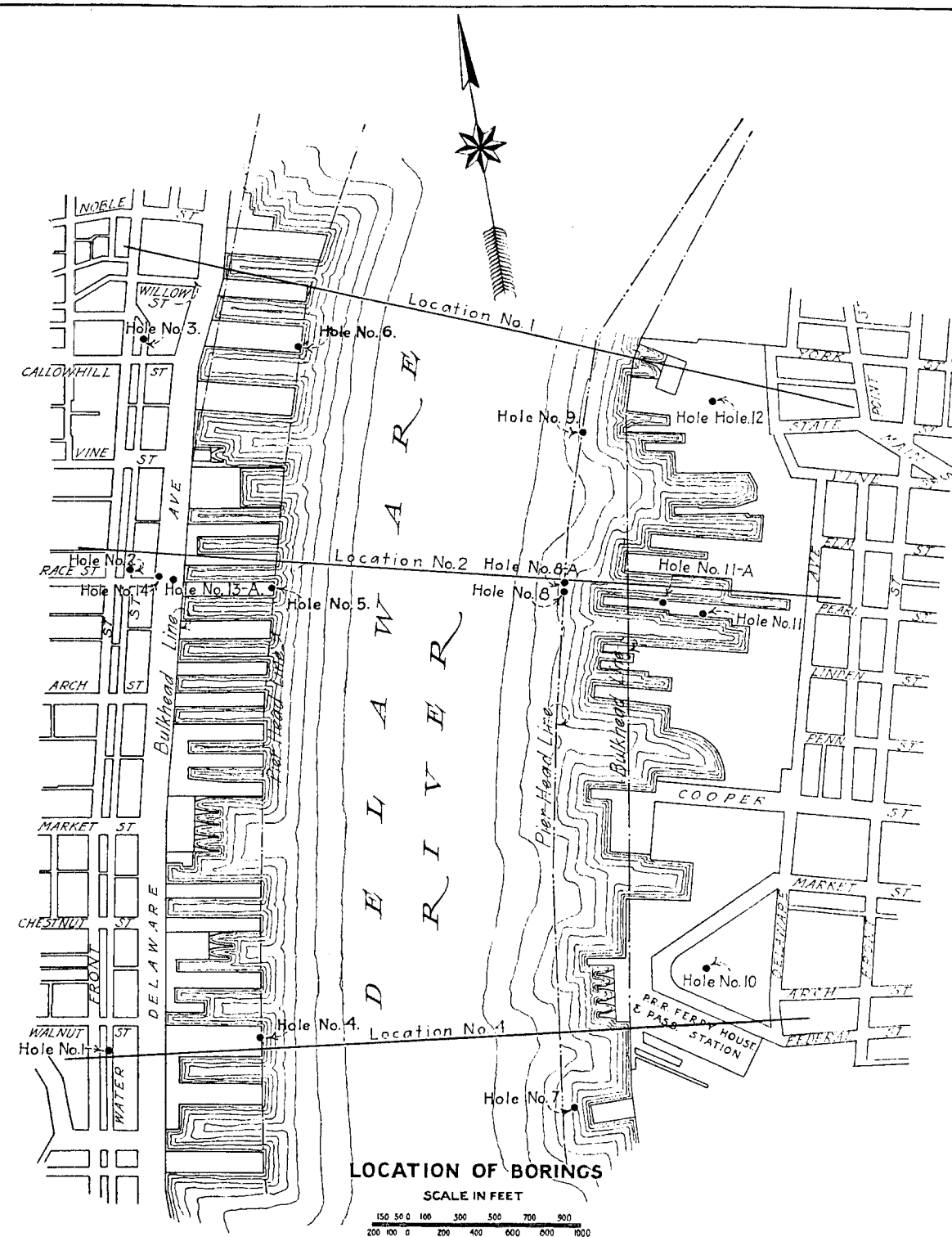
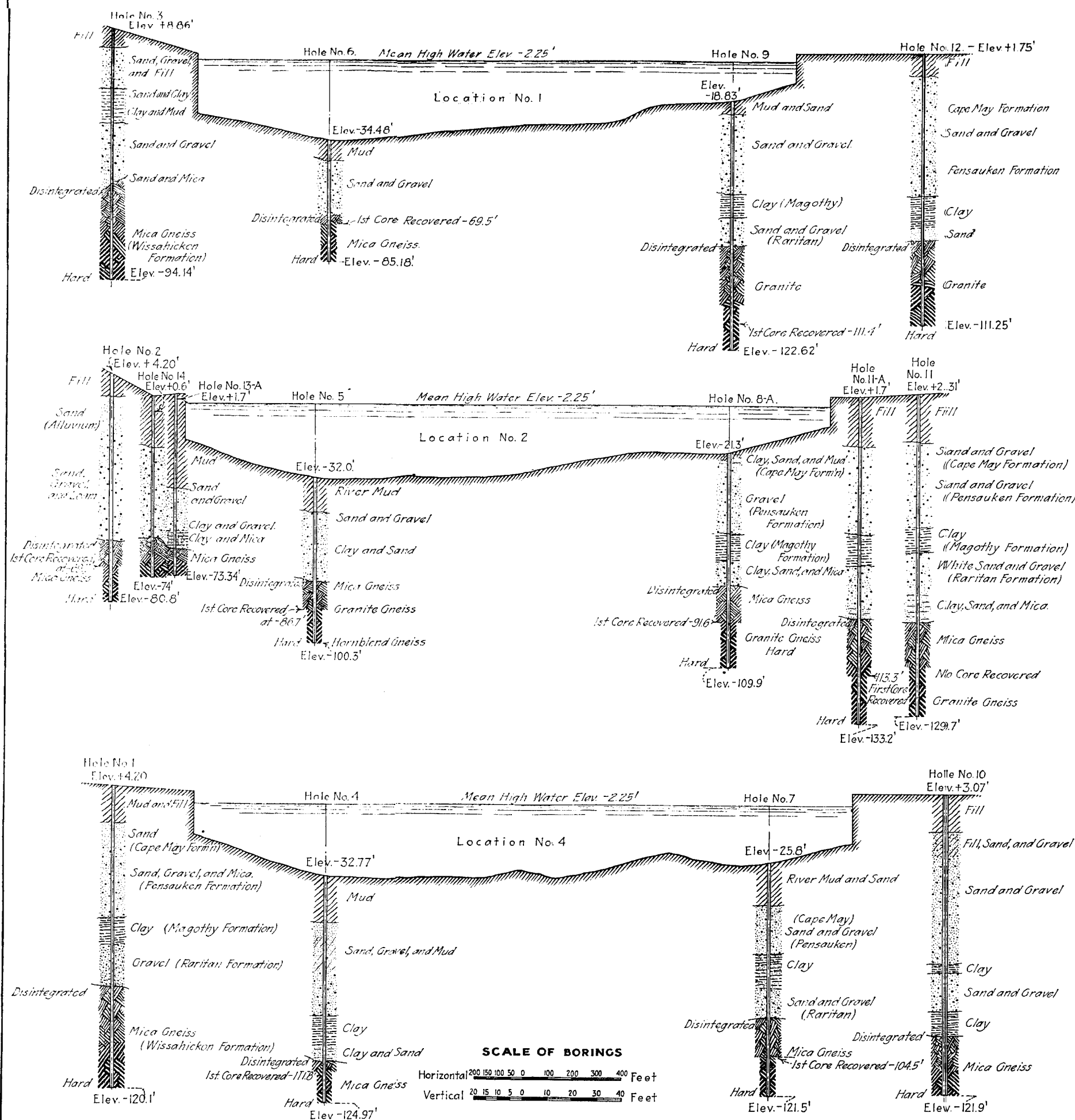
MAP OF BRIDGE LOCATIONS

DATED: JUNE 1st. 1921





DISTRIBUTION & CLASSIFICATION OF FERRY TRAFFIC						
FERRY ROUTES	TEAMS AND WAGONS	MOTOR TRUCKS	PASSENGER AUTO-MOBILES	SPECIAL	TOTAL AVERAGE ONE DAY	PERCENTAGE OF TOTAL
Shackamaxon St. to Cooper's Point	95	135	156	3	389	7%
Vine St. to Cooper's Point	115	147	69	21	352	6%
Market St. to Federal St.	293	867	1772	56	2988	55%
Chestnut St. to Kaighns Pt.	238	413	309	33	993	18%
South St. to Kaighns Pt.	201	253	141	32	627	12%
South St. to Gloucester	33	28	11	2	74	2%
TOTAL AVERAGE ONE DAY	975	1843	2458	147	5423	100%
PERCENTAGE OF TOTAL	18%	34%	45%	3%	100%	



GENERAL NOTES

Elevations Given are Referred to Philadelphia City Datum

Location No. 1 (Spring Garden and State Streets)

Location No. 2 Recommended Location, (Franklin Square and Pearl Streets.)

Location No. 4 (Washington Square and Federal St)

No Borings taken at Location Nos. 3 and 5.

LEGEND

Fill	
Sand	
Gravel	
Clay	
Rock	

DELAWARE RIVER BRIDGE JOINT COMMISSION
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PHILADELPHIA, PA. & CAMDEN, N. J.

BORINGS

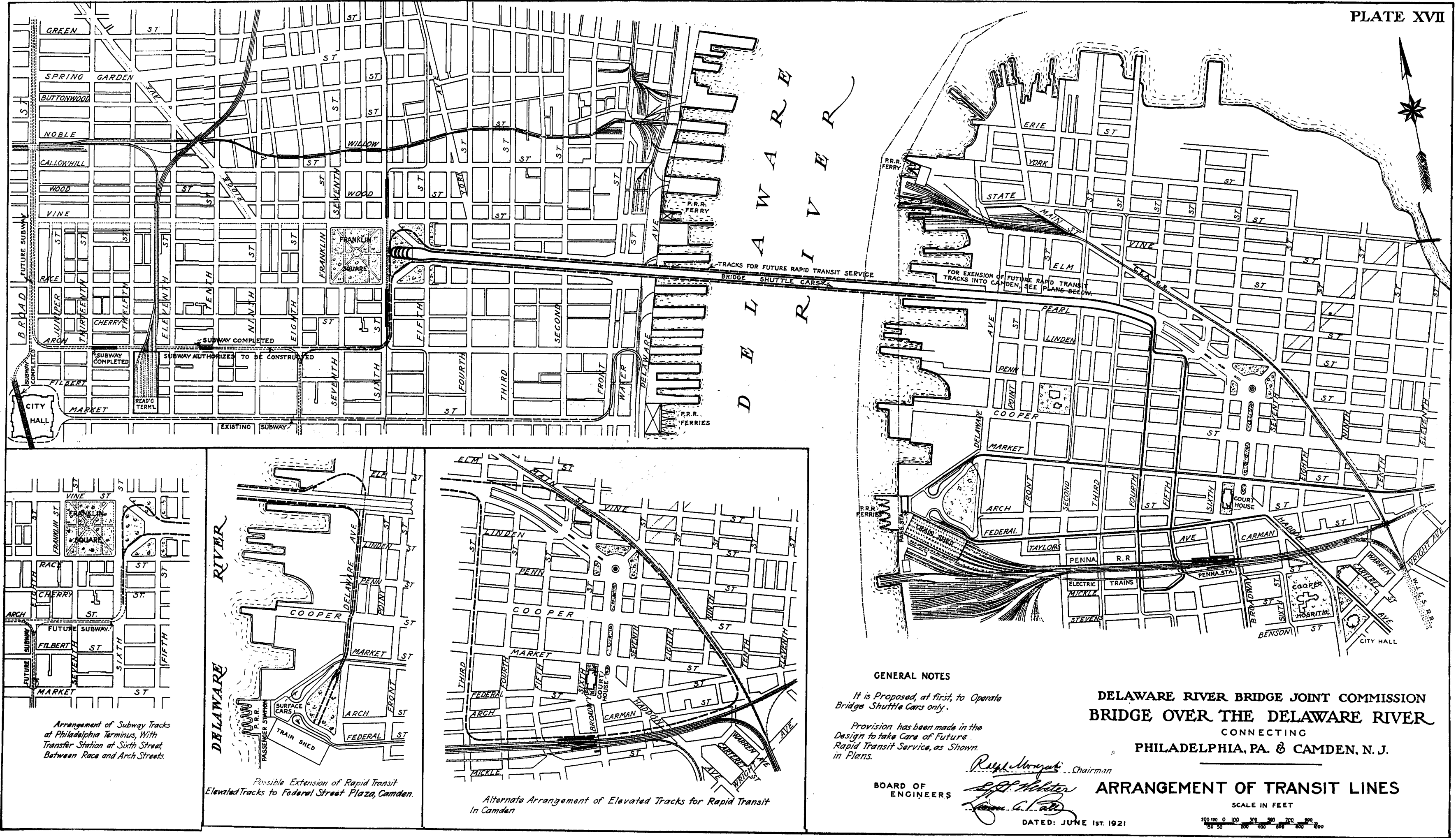
BOARD OF
ENGINEERS

Ralph M. Wozniak Chairman

L. J. Webster

James A. Lacy

DATED: JUNE 1st, 1921



GENERAL NOTES

It is Proposed, at first, to Operate Bridge Shuttle Cars only.

Provision has been made in the Design to take Care of Future Rapid Transit Service, as Shown in Plans.

BOARD OF ENGINEERS

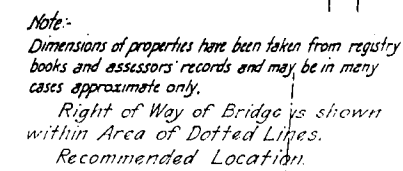
Raymond Morgan Chairman
W. H. Weston
James C. Ladd

DELAWARE RIVER BRIDGE JOINT COMMISSION
BRIDGE OVER THE DELAWARE RIVER
CONNECTING
PHILADELPHIA, PA. & CAMDEN, N. J.

ARRANGEMENT OF TRANSIT LINES

DATED: JUNE 1st. 1921

SCALE IN FEET
200 100 0 100 200 300 400 500 600 700 800



DELAWARE RIVER BRIDGE JOINT COMMISSION
BRIDGE OVER THE DELAWARE RIVER
CONNECTING
PHILADELPHIA, PA. & CAMDEN, N. J.
PROPERTIES AFFECTED, PHILADELPHIA, PA.

BOARD OF
ENGINEERS

Reed W. Gray Chairman

Edw. H. Whistler

Frederic C. Ball

DATED: JUNE 1ST 190

DATED: JUNE 1st, 1921

PROPERTIES AFFECTED, CAMDEN, N.J.

SCALE IN FEET

100 75 50 25 0 50 100 150

BOARD OF
ENGINEERS

Reyn. Morgan Chairman
E. J. Webster
Thomas C. Ford

DATED: JUNE 1ST 1921

